ELLIOTT & WEBSTER

ELECTRICAL and ELECTRONICS MACHINIST'S MANUAL

For Newspaper Composing Rooms

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ELECTRICAL
and
ELECTRONICS MANUAL

For Newspaper Composing Room Machinists

Compiled and Written by

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PREFACE

The content of this manual is the result of two series of in-plant instruction classes for machinists conducted at the Oklahoma Publishing Company, Oklahoma City, Okla.

The first class dealt with basic electricity and its application to composing room equipment, especially linecasting machines. The second series (on which this manual is based) was handled by taking one item at a time, fully discussing its operation, but holding theory to a minimum consistent with adequate explanation of principles involved. Mathematics were introduced in discussions and in the manual only where they had a practical application to composing room work. Schematic diagrams were used in discussing methods of testing and machine repair.

References have been made to pertinent chapters of "Basic Electricity" and "Basic Electronics," the texts used in the first series of training courses.

The following subjects are discussed in this manual; the numbers indicate the order of appearance and not the book page number.

1. "Working With Schematics" — How to read diagrams. Symbols illustrated.
2. "Test Equipment" — Do's and don'ts in using volt ohmmeters, tube testers and capacity resistance bridge.
3. "Electric Pots and Controls." — How they work and how to test for troubles.
4. "Electric Motors" — A discussion of the various types used on composing room equipment; what makes them run. Repairs that can be made in the shop.
5. "Relays and Solenoids." — Relays and solenoids are coming into more frequent use in composing rooms. This section covers several types with attention given to operation and maintenance.
6. "Transformers and Rectifiers" — A study of DC (direct current) power supply. This section is closely related to section five. Together these sections pave the way to work outlined in sections 7, 8 and 9.
7. "Classified Rule Inserter" — The memory circuit. Operation sequence and trouble shooting on the unit.
8. "Electric Quadder Controls" — Two types of quadders are discussed. Memory circuits and operation sequences explained with drawings and photographs.
9. "Selecto-spacer" — A study of the electrical circuits and component parts. Operation sequence explained with detailed drawings.
10. "Vacuum Tubes and Photo-cells." This section serves as a preface to material contained in sections 11 and 12. Testing chart is included.
11. "Electrical Safeties." — Electrical Safeties on Linotype Comets and mixers such as Model 36 are discussed in this section.
12. "Electronic Mat Detector" — Principle of Operation; circuit diagrams; testing and adjusting unit controls.

—THE AUTHORS

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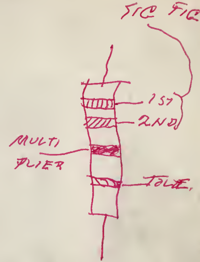
Mergenthaler Linotype Company

Star Parts, Inc.

The Heath Company

Shaffstall Equipment Company

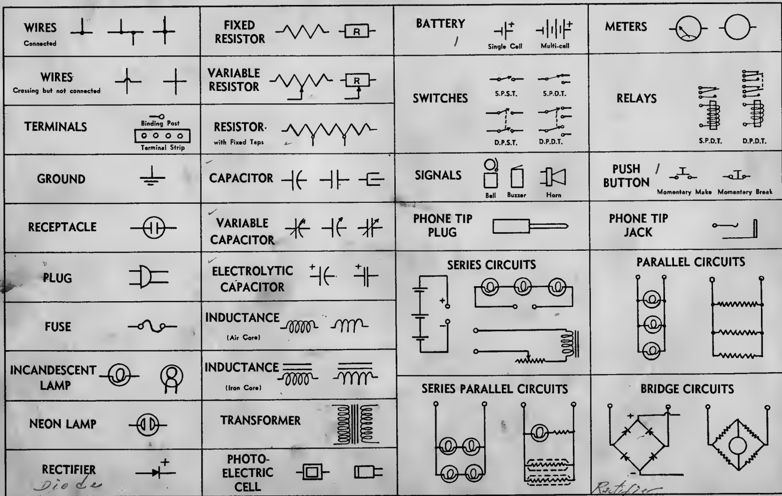
	SIGNIFICANT FIGURE	MULTIPLIER		TOLERANCE
BLACK	0	1		
BROWN	1	10	0	
RED	2	10^2	00	
ORANGE	3	10^3	000	
YELLOW	4	10^4	0000	
GREEN	5	10^5	00000	
BLUE	6	10^6		
VIOLET	7	10^7		
GRAY	8	10^8		
GOLD				10
SILVER				20



$I = \frac{W}{V}$

$W = VI$

$V = \frac{W}{I}$



WIRES
Connected
WIRES
Crossing but not connected
TERMINALS
Binding Post
Terminal Strip
GROUND
RECEPTACLE
PLUG
FUSE
INCANDESCENT LAMP
NEON LAMP
RECTIFIER
Diode
FIXED RESISTOR
R
VARIABLE RESISTOR
R
RESISTOR
with Fixed Taps
CAPACITOR
VARIABLE CAPACITOR
ELECTROLYTIC CAPACITOR
+
INCUCTANCE
(Air Core)
INDUCTANCE
(Iron Core)
TRANSFORMER
PHOTO-ELECTRIC CELL
BATTERY
Single Cell
Multi-cell
SWITCHES
S.P.S.T.
S.P.D.T.
D.P.S.T.
D.P.D.T.
SIGNALS
Bell
Buzzer
Horn
PHONE TIP PLUG
SERIES CIRCUITS
SERIES PARALLEL CIRCUITS
METERS
RELAYS
S.P.D.T.
D.P.D.T.
PUSH BUTTON
Momentary Make
Momentary Break
PHONE TIP JACK
PARALLEL CIRCUITS
BRIDGE CIRCUITS
Rectifier

Working With Schematics

Ability to read and interpret schematic diagrams is a must for the man who would do construction, repair or maintenance of electrical or electronic equipment. A schematic contains virtually all the information needed to understand the apparatus to which it pertains. With this information and an understanding of the mechanical construction, the workman is prepared to analyze and diagnose troubles as they occur.

Schematics are written in a special kind of sign language. Signs, or symbols, are used to represent various components and these symbols usually bear no resemblance to the physical appearance of the part they represent. The first step toward working with schematics is to learn the various symbols and be able to translate to the actual parts they represent. To aid you in learning the language of the schematic, there is a chart illustrating the most commonly used symbols accompanying this lesson. Study these signs until you know at a glance what they stand for. If you do not recognize the actual components represented by some of the symbols, check them on the sheet and bring it to the shop and ask to be shown examples of the parts represented. You must be able to tie the symbol to the part it represents, because, while you will be reading the diagram, you'll be working on the actual apparatus.

If it is true that the symbols used bear little resemblance to the parts they represent it is doubly true that the schematic diagram bears small likeness to the finished wiring job. There is good reason for this. The aim of the draftsman is to make the schematic as clear and easy to read as possible. He will lay out the drawing with parts spaced to avoid crowding and wires will be represented by straight lines drawn parallel or at right angles. On the other hand the man wiring the apparatus will be faced by problems peculiar to the type of equipment. Space restrictions may require that parts be compactly placed; certain wires may have to be kept short and direct or perhaps certain parts or wires may have to be isolated or shielded from others. In any case the wires will not follow the precise patterns of the drawing. You will find, however, that any two points connected by a line on the diagram will be joined by a wire on the apparatus.

CIRCUIT CONNECTIONS

Electrical circuits are classified in five general types, according to the way component elements are connected. You should be able to recognize these circuit types as well as the individual symbols. They are: simple, series, parallel (or multiple), series-parallel and bridge.

A simple circuit is one having only one element connected to a voltage source.

In series connection the components are arranged like beads on a string and current must flow through each of the circuit elements in turn on its way back to the source.

When circuit elements are arranged side by side with ends connected, you have parallel connection. The schematic diagram of such a circuit may be likened to a ladder—the leads forming the sides and the components forming the rungs. In parallel circuits, each element receives full voltage supplied by the source, but only a portion of the total current flows through each element.

As its name implies, series-parallel connection is a combination of the two. In this circuit, current flows through series elements singly and in succession, but divides to flow simultaneously through the parallel portions of the circuit.

There is a fifth type of circuit you will meet from time to time. This is the bridge connected circuit. A circuit is bridge connected if current from a single source can flow in opposite directions in at least one of its components. This circuit is much used with rectifiers and certain types of instruments.

Examples of each of these circuits will be found on the chart of symbols.

TRACING A CIRCUIT

In order for current to flow, there must be a continuous conductive path leading out from a voltage source and return. The circuit is completed internally through the source. Consider the diagram in Fig. 1. This represents a battery connected to a lamp. The arrows indicate the electronic flow. Current leaves the battery cell from the negative terminal, flowing through the lamp and back to the positive terminal of the cell. This same current is also flowing inside the battery from the positive to the negative element.

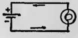


Fig. 1

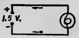


Fig. 1a

Working drawings, especially those dealing with apparatus connected to power lines, usually indicate only a connection to a power source. Fig. 1a is the same as Fig. 1 except that the battery symbol is omitted and connection to a power source indicated. While Fig. 1 and Fig. 1a represent simple circuits, they are nevertheless complete. The average circuit diagram contains various numbers of such circuits. Being able to trace and isolate them in the complete diagram enables one to de-

termine the function of each circuit and relationship of the individual circuits to each other.

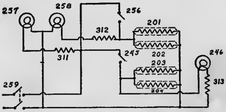


Fig. 2

To illustrate this, let's take a diagram for a 220-volt A. C. pot crucible and mouthpiece control. Fig. 2 is drawn from a diagram in the book "Linotype Machine Principles"—Fig. 37-13 on page 201. For a pictorial view of this control see Fig. 33-13, page 198. The numerals used in Fig. 2 to identify component parts are the same as those used in Figs. 33-13 and Fig. 37-13 referred to above. In this diagram (Fig. 2) there are five individual circuits (as illustrated in Figs. 2a through 2e).

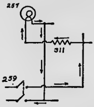


Fig. 2a

Referring to Fig. 2a, notice that we have a complete circuit consisting of power switch 259, connecting to a 220 volt A. C. power source, power indicating lamp 257 and power lamp resistor 311. (Notice the similarity of this circuit to that in Fig. 1a.) The lamps used in this equipment are rated 110 volts and the resistors are necessary to drop the 220 line voltage to the 110 volt figure for the lamps. When switch 259 is closed, current flows, as indicated by arrows, along the upper conductor, through resistor 311 and lamp 257 and back to the switch through lower conductor. This is true, of course, of one half cycle. During the alternate half cycle, current flows in opposite direction to that indicated by arrows.

As stated above, this circuit is complete and is independent of other apparatus with which it is connected. When switch 259 is closed, lamp 257 glows indicating power is on, which is the purpose of the circuit. It does not indicate that the rest of the apparatus, or any part of it, is functioning.

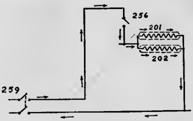


Fig. 2b

Looking now at Fig. 2b, we see another circuit consisting of switch 259, crucible automatic switch 256 and crucible heaters 201 and 202. With both switch 259 and switch 256 closed, current will flow through the circuit as indicated by the arrows. Notice that the heaters are connected in parallel and that the current divides, part flowing through heater 201 and part through heater 202. Leaving the heaters, the currents unite to flow along the lower conductor back to switch 259. In this, as in all other figures in this paper dealing with A. C., the arrows indicate current flow during a half cycle. On alternate half cycles current flow will be reverse to that indicated by arrows. Switch 256 is operated by the crucible bulb and bellows. When crucible temperature falls below a pre-set value, the switch will close, starting the current flow as described above. As temperature rises, the bellows expands, opening the switch and cutting off the current.

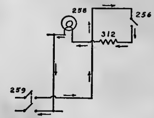


Fig. 2c

As a means of indicating whether current is on or off in circuit 2b, we have the circuit in Fig. 2c. This includes switch 259, crucible automatic switch 256, crucible lamp resistor 312 and crucible indicating lamp 258. Assuming that both switches 259 and 256 are closed, current flows along the upper conductor through switch 256, resistor 312 and lamp 258, thence back to switch 259. Thus we see that with power on through switches 259 and 256, the crucible indicating lamp 258 will glow. As temperature rises and the bellows acts upon switch 256 causing it to open, the lamp will cease to glow. We see that current flow in this circuit is controlled by the same switches acting under the same conditions as circuit in

2b, therefore when the lamp glows it indicates current is flowing through the circuit 2b and the "heat is on."

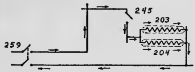


Fig. 2d

Our fourth circuit is shown in Fig. 2d. This circuit is identical to Fig. 2b and functions in the same way. Only different identifying numbers tell us that this circuit controls a different section of the pot heating apparatus. No. 245 identifies the mouth and throat automatic switch; 203 and 204 are mouth and throat heaters. Circuit 2d, then, is the throat and mouthpiece circuit, which is controlled automatically by action of the mouthpiece bulb and bellows acting upon switch 245

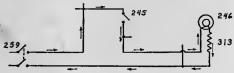


Fig. 2e

The fifth and last circuit is Fig. 2e, comprised of switch 259, mouth and throat automatic switch 245, mouth and throat lamp 246 and mouth and throat lamp resistor 313. Electrically, this circuit is identical to Fig. 2c and like Fig. 2c its purpose is to indicate. Since the circuit is controlled by switch 245 which also controls Fig. 2d, it will operate to indicate heat on or heat off in the mouth and throat heaters of circuit 2d.

Figs. 2a through 2e were drawn to illustrate how the complete diagram is composed of a number of individual circuits interconnected, each doing a part of the overall job. To the man accustomed to working with schematics, a diagram like Fig. 2 would be clear at a glance and there would be no need to sketch sections of it. However schematics often are very complex and it is helpful to dissect them in this manner for study and analysis.

SOME FACTS ABOUT CIRCUITS

When classifying circuits for type, disregard the voltage source, even when it is drawn in as part of the diagram.

Simple circuits never have more than one element and circuits with only one element are always simple circuits. In such a circuit the element receives the full circuit voltage from the source and carries the total current.

A series circuit must always have two or more elements. The source voltage will be divided among the elements in proportion to their individual resistance or inpedance. Each element carries full circuit current. Failure or removal of a single component will disrupt the circuit.

A parallel circuit must have two or more elements, each of which receives the full circuit voltage. Total current for the circuit will be divided among the elements according to individual characteristics. Any component may be removed without affecting the remainder of the circuit.

A series parallel circuit always has three or more elements. Current flows through the series elements in sequence and divides to flow through parallel groups simultaneously. Each series component carries the total circuit current while parallel elements carry a portion of the current, depending on their individual characteristics and the voltage impressed on them. Voltage received by each element depends upon total circuit voltage, character of the element and its relation to other parts of the circuit.

MVT. MADE IN U.S.A. BY THE SIMPSON ELEC. CO., CHICAGO, ILL.
OHMS
DC
AC
DB
OHMS PER VOLT
THE HEATH COMPANY
Heathkit
15A
.5A
15A
1500V
RX10K
500V
RX100
OHMS ADJ.
DB OUTPUT
AC
DC+
DC−
150V
RX1
50V
150µA
5V
15MA
1.5V
150MA
COMMON
5KV DC
5KV AC
MODEL MM1

Test Equipment

To facilitate the testing of its electrical equipment, the company has provided a fine complement of testing instruments. With this equipment, it is possible to test practically any part of any electrical device in the composing room. The following notes are intended as a guide to the operation of the three most important pieces of equipment — the voltohmmeter (VOM), the tube checker and the resistance-capacity bridge. In these notes, use of the instruments in a general way will be discussed. In later lessons, specific applications will be taken up.

THE VOLTOHMMETER

The voltohmmeter, sometimes called a multimeter or multitester, as its name implies, combines the functions of several instruments in one. Essentially, it consists of one meter movement wired through switches to various resistors, batteries and capacitors to give readings on voltage, current and resistance. Most VOMs today have provision for both DC and AC readings. With most of them, it is also possible to measure decibels and make rough tests of capacitors.

There are many fine meters on the market today and some machinists own personal instruments of various makes. It is not practical in these notes to discuss operation of more than one VOM, therefore discussion will be limited to the company-owned instrument. Those men owning their own meters will already be familiar with their use, and test procedures, to be discussed later, will apply to all makes.

DESCRIPTION

The Heath MM-1 consists of a meter movement having a full scale sensitivity of 50 microamperes. Centered on the panel below the meter dial is the rotary range switch. To the left of this is the ohms-adjust knob and to the right is the function switch. Immediately below the meter dial are three jacks for DC current ranges and at the bottom of the panel are four jacks—two at the left for most meter functions and two at the right for high voltage ranges. The following ranges are available:

DC Volts: 1.5-5-50-500-1500-5000 at 20,000 ohms per volt

AC Volts: 1.5-5-50-150-500-1500-5000 at 5000 ohms per volt

Direct Current: 150 microamperes, 15-150-500 milliamperes, 15 amperes

Resistance: Three ranges giving readable indications from o.2 ohms to 20 megohms

Decibels: -10 to 65 db

USING THE VOM

The following paragraphs on operation of the VOM are from the manual furnished with the MM-1. Some of the uses described are applicable to radio and TV equipment and will probably never be used in servicing composing room apparatus, but are included here as a part of a complete description of the instrument.

DC VOLTAGE

To measure DC volts, plug the black test lead into the common or minus test jack and the red test lead into the adjacent plus jack. The function selector switch should be set to DC+ and the range switch to a range higher than the voltage being measured. The voltages marked on the range switch refer to full scale deflection of the meter for that specified voltage. If the voltage being measured is unknown, set the range switch for the highest voltage range first. The black test lead should be connected to the negative side of the circuit and the red test lead to the positive side.

CAUTION: These connections must be made with the equipment under test turned off. If the meter reads backward, the voltage is opposite in polarity than supposed. It is not necessary on the MM-1 to reverse the test leads. Turn the selector switch to the DC— position. The meter will now read up-scale. The meter scale is marked in black for DC, 0-15 and 0-50 volts. To read 1.5 volts, the reading is taken on the 0-15 scale and the decimal point moved one place to the left. To read 150 or 1500 volts, the reading is taken on the same scale and one or two zeros added. The same factors apply to read 5, 500 or 5000 volts on the 0-50 volt scale. To read 5000 volts DC, the red test lead is moved from the plus jack to 5KV DC jack and the range switch set to tne 1500 volt position.

WHEN THE METER IS USED ON VOLTAGES OF THIS MAGNITUDE, HAVE ALL CONNECTIONS SET UP BEFORE TURNING EQUIPMENT ON AND DO NOT TOUCH THE METER, TEST LEADS OR ANYTHING ASSOCIATED WITH THE CIRCUIT WHILE THE CURRENT IS ON. It is not recommended that the meter be left connected in the circuits having very high voltages.

AC VOLTAGE

The function selector switch is placed in the AC position and the range switch set to the desired voltage range. The test leads remain in the same jacks used for DC. AC voltage is read on the red scales of the meter and the same method of reading the scale applies that was used for DC with one exception. 1.5 volts AC is read on a separate scale marked 1.5 VAC. It is not necessary to observe polarity when connecting test leads. However, the same precautions of connecting the leads with equipment OFF applies. To measure 5KV AC,

the red test lead is moved from the plus jack to the 5KV AC jack and the range switch is set to the 1500 volt position. HAVE ALL CONNECTIONS PRE-SET AND DO NOT TOUCH THE METER, TEST LEADS OR ANYTHING ASSOCIATED WITH THE CIRCUIT WHILE CURRENT IS ON. It is not recommended that the meter be left connected in the circuits carrying high voltage.

OUTPUT-DB

With the test leads in the common and plus jacks, set the function switch to DB OUTPUT position and the range switch to the desired voltage position. As explained in the section on circuit description, a .1 mfd condenser is now placed in series with the normal AC voltage ranges. This blocks the DC component present at points such as the plate of an audio amplifier tube, allowing only the audio voltage to be measured. When aligning a radio receiver, it is usually necessary to have some visual indication of receiver output. For this purpose, the output meter may be connected from the plate of the last audio tube to ground.

AC Volt Scale	DB SCALE
0-15 volts	Read db directly
0-5 volts	Add 10 db to the reading
0-50 volts	Add 30 db to the reading
0-150 volts	Add 40 db to the reading
0-500 volts	Add 50 db to the reading
0-15000 volts	Add 60 db to the reading

OHMMETER

To use the ohmmeter, the function selector switch is set to the DC+ position and the range switch to any of the three ohm ranges, RX1, RX100, or RX10K. The test leads are inserted in the common and plus jacks. With the instrument thus adjusted, short the test leads together and vary the OHMS ADJ. control to obtain full scale reading on the meter. The unknown resistance is now connected across the test leads. On the RX1 range, the scale is direct reading, for the RX100 and the RX10K, the scale reading is multiplied by 100 or 10,000.

CAUTION: Do not connect the ohmmeter into any circuit having voltage present.

MICROAMMETER - MILLIAMMETER AMMETER

To measure current, the function selector switch may be set to the DC+ or DC— position, depending upon the direction of current flow. The test leads are then connected in series with the load circuit, never parallel, as this would put the meter across the voltage supply. Damage to the meter will invariably result. To measure very small amounts of current such as tube grid current, the range switch is set to the 150 microampere position and the test leads inserted in the common and plus jacks.

CAUTION: It is advisable to set the range switch to the 150MA position first to be sure there is not a higher current than expected at the point under test.

The readings for 150 microamperes, 15 milliamps, 150 milliamps and 15 amperes are made on the 0 to 15 DC volt scale. The .5 ampere readings are made on the 0 to 50 volt scale. With the test leads in the common and plus jacks, the readings from 150 microampere to 150 milliampere are made by use of the range switch. To measure .5 or 15 ampere, set the range switch to the 150MA position. Insert the black test lead in the —15A jack and the red test lead in the jack marked .5A or 15A. If the meter reads backward, set the function switch from DC+ to DC— to correct for the current polarity.

CONDENSER TESTING

Any good paper or oil condenser should show an infinite resistance on the RX10K range. If the condenser has a large capacity, it will show one kick on the meter as the condenser charges, then read infinite resistance.

When testing electrolytic condensers, connect the positive meter lead to the plus side of the condenser. A good electrolytic condenser will show a large deflection of the meter which will slowly return to a relatively high resistance. A high voltage electrolytic condenser should show a reading of .5 to over 1 megohm and a low voltage condenser should show a reading of .1 to over .5 megohms.

The preceding paragraphs were lifted from the instruction manual for the MM-1 VOM. Note that nowhere in these instructions is the measurement of AC current mentioned. This instrument has no provision for measuring AC current and no such measurement should be attempted.

Remember the caution: NEVER connect an ohmmeter to a circuit where voltage is present. Damage to the meter will almost certainly result. Another point to remember is to be sure the voltage or current range is high enough to meet conditions in the circuit. If you are not sure of the value of the voltage or current to be tested, set the range switch to the highest range, then re-set as indicated.

When making measurements on high resistance ranges, avoid touching tips of test prods or touching parts of the circuit, with your hands. You may place your body in the circuit and get a false reading as a result.

In using the ohmmeter, the meter must be "zeroed in" for each range setting and must be reset each time the range switch is changed if accurate readings are to be obtained. Difficulty in adjusting the meter usually will indicate run-down batteries in the meter, and should be reported at once.


BAD
?
Heathkit
TUBE CHECKER
FILAMENT
PLATE
5AN8
5AQ5
5AS4
20J8
19X8
19X3

THE TUBE CHECKER

The Heath Tube Checker, Model TC-3, will accommodate practically any vacuum tube used in home radio and TV and in small industrial devices. It makes the following tests available: Emission, short, leakage, open element, filament continuity.

It should be remembered that no tube tester reproduces the exact conditions under which the tube normally operates. About the best that can be done is to provide a set of operating conditions and test for one of the tube's characteristics as an indication of its quality. Designers of the TC-3 chose cathode emission as the quality to test for. Other tests mentioned above are incidental.

In some cases, a tube may function satisfactorily in the equipment in which it is used, yet register doubtful or bad on the checker. This could come about if the tube is used under conditions requiring only a low cathode emission where it performs well enough, but is unable to show emission strong enough to register good on the tube checker. Another case where indications of the checker might not be reliable would be when testing the OA4G. The critical thing here is the grid voltage at which the tube "fires." Such a tube may show up perfect on the emission test and still its firing point may have shifted so far that compensating adjustments cannot be made on the equipment on which it is used.

All of which is not to say that findings of the checker are worthless. In most cases, indications of the instrument may be relied on and instances, such as the two mentioned above are comparatively rare.

Looking at the panel of the TC-3, we see a large meter dial centered at the top of the panel and immediately below it an illuminated roll chart. Centered at the bottom of the panel are ten levers, lettered A through K, each lever having three positions: top, center and bottom. Tube sockets are arranged in a symmetrical pattern on either side of the meter. There are sockets for 4-pin, 5-pin, 6-pin, 7-pin, 7-pin miniature, 7-pin sub-miniature, octal, loctal and 9-pin tubes. In addition there is a blank socket, a neon lamp to indicate shorts and the 7-pin socket contains a socket for pilot lights at its center.

At the upper left, there is a slide switch labeled "Short-Leakage" and across the panel at the upper right another slide switch labeled "Short Adjust Line-Test." Below the sockets on the left, there is a rotary tap switch marked "Filament" and beneath this another marked "Plate." Under the sockets at the right is a switch labeled "Set Line" and below it at the bottom of the panel another marked "Type." These parts will be referred to by name in the following notes on operating the checker.

USING THE TUBE CHECKER

To use the tube checker, first rotate the roll chart to the listing of the tube to be checked. The chart will indicate setting of the various switches to make the test. The following instructions for operating the tube checker are from the Heath manual:

1. Turn the Set Line control until the meter pointer falls within the Line Test block.
2. Set the Type switch to the number shown on the chart.
3. Set the Filament selector to the voltage shown on the chart.
4. Set the Plate control according to the chart information.
5. Set the Lever switches to the T-top and B-bottom position as shown in the top and bottom columns on the chart.
6. Insert the tube (*) and reset the Set Line control if necessary.
7. Check the tube for shorts by moving levers shown in light type through the two positions, returning to the position shown on the chart. The Test switch remains in the Short position for this test. The Short-Leakage switch should be in the Short position. A shorted tube is indicated by a steady glow of the neon bulb. Disregard neon bulb flashing as the lever switches are moved. It is possible that some serious short circuits will momentarily overload the power transformer. This condition will be indicated by complete dim out of the panel lamps. Do not allow the Tube Checker to operate under this extreme condition for any length of time. Make the test as quickly as possible in order to obtain the desired information.
8. Check the tube for leakage between elements by moving the Short-Leakage switch to the Leakage position and repeating the short test as outlined above.
9. After allowing sufficient time for the tube to reach operating temperature, check for quality by moving the test slide switch to Test position. If the meter falls in the green scale, the quality of the tube is good.
10. Check for open elements as follows: holding the slide switch in the Test position, move each lever in the Top position (only those shown in light type) to the Bottom position and return. Satisfactory tube elements (those properly connected to their pins) are indicated by a decrease in meter reading. The grid element usually shows a large decrease, while a screen or plate may show only a slight decrease.

    NOTE: If the meter indication in the quality test is off scale, reduce the meter reading to an on-scale reading by turning the

* Pin positions and keyways determine tube positioning on all sockets except subminiature. For subminiature tubes, position color dot adjacent to color dot on panel.

Heathkit CONDENSER CHECKER
CLOSED SHADOW INDICATES EXCESSIVE LEAKAGE
HEATH COMPANY
CAP. TEST
LEAKAGE TEST
25 V.
150 V.
450 V.
AC OFF
POWER FACTOR
ELEC.
PAPER & MICA
MODEL C-3
EXTENDED RANGE
RES.
CAP.
NORMAL
LEAKAGE
MILLIAMPERES

Plate control counterclockwise, then proceed with the open element test.

11. To check filaments, filament taps and internal connections for continuity, set the Filament selector to .63 volts. Move each lever shown in dark type through each of its other two positions. Always move only one lever at a time. Satisfactory filaments, taps and internal connections will be shown by a bright glow of the Short test indicator.

In any of the above tests, should the tube prove to be faulty in some respect, the defective element can be traced by comparing the lever switch in question with a base diagram of the tube. Lever A switch corresponds to tube pin 1, lever switch B to tube pin 2, etc.

Multiple tube types (tubes which contain more than one set of elements) are indicated on the chart by a bracket set of listings, one for each test to be made on the tube. The tester is set up according to the test in each line and checked through all of the tests as outlined in the preceding steps.

Check pilot lights by setting the Filament selector to the proper voltage and inserting the pilot light in the socket found in the center of the large seven pin socket. This is a universal type pilot light test socket and does not require that the lamp be permanently inserted. It is only necessary to hold the pilot lamp so that the side wall of the base and the center pin of the lamp make contact with the corresponding points in the lamp socket.

CONDENSER CHECKER

(Resistance-Capacity Bridge)

While condensers can be tested on an ohmmeter, the best that can be done by this method is to determine that the capacitor is not shorted, and if it is large enough to show a kick of the meter needle when charging, it can be determined that it is not open. There are ways to pass an AC current through a condenser and roughly measure its capacity on a voltmeter. However, for quick, accurate determination of the capacity and condition of a condenser, the instrument to be described here leaves little to be desired. It will also make accurate measurements of resistors over a wide range of values.

DESCRIPTION

The Heath Model C-3 is a compact instrument, having all its controls grouped on a panel measuring 9½ in. wide by 6½ in. high. The dominant feature is the main control, centered on the panel. At the upper left corner is the electron beam tube which indicates state of balance of the bridge. Below this, at the lower left, is the power factor control. At the upper right is the range selector switch and below it at the lower right is the leakage test switch. The main control knob carries a transparent pointer which sweeps the graduated scales covering the ranges of the instrument.

Below the main control are three combination binding post-tip jacks, which will accept wire or pig-tail terminals through a hole at the base, or banana plugs may be inserted directly into the ends of the jacks.

The following instructions for operating the Heath C-3 are from the manual accompanying the instrument.

OPERATION

The operation of this instrument is basically simple and through continued use the serviceman will perform the various test functions automatically. In all test procedures, the center binding post is considered positive and is common to all tests. The black test lead should be connected to the right binding post for capacity measurements and transferred to the left binding post for resistance measurements. For service convenience, liberal length test leads are supplied. For making accurate measurements of small capacities or low value resistors, the test leads should be removed entirely and the component under test connected directly to the instrument binding posts.

Resistance measurements are read directly on the outer calibrated scale when the selector switch is set at the R position. With the switch set at RX100, it is merely necessary to add two zeros to the resistance measurement obtained. Resistance measurements are made by connecting the left and center binding posts or test leads to the component under test and rotating the main control for a balance or null indication. The total range of resistance measurements is from 100 ohms to 5 megohms.

To measure capacity, it is merely necessary to transfer the black test lead to the capacity binding post terminal. You will note that the dial is calibrated in three capacity ranges plus an extended range for checking extremely high capacity values. The ranges are in logical sequence working from the inner edge of the calibrated scale toward the outer or resistance scale as the selector switch is progressively advanced through succeeding ranges. The calibration for the extended capacity range will be found on the extreme inner portion of the dial calibration. This calibration was deliberately placed in this manner to minimize confusion on the three capacity ranges most commonly used. For applications requiring the testing of paper or mica condensers, the power factor control should be rotated to its maximum counter-clockwise position until a click of the switch is heard and the pointer knob is at the paper-mica position. The test leads should be connected to the center and right or capacity binding post. The test lead alligator clips should be clipped to the condenser under test and with proper setting of the capacity range switch, it will be possible to obtain a null indication by rotating the indicator knob. The capacity can then be read di-

rectly on the calibrated scale. If the condenser being measured is connected in a circuit, it will be necessary to disconnect at least one side of the condenser from the circuit so that associated wiring will not adversely affect the information supplied by the condenser checker. To measure extremely small capacity values, it would be desirable to remove the condenser from the circuit entirely and connect it directly to the binding posts, removing the test leads entirely. The value of the inherent minimum capacity for your particular instrument should be subtracted from the reading obtained.

After the capacity value has been determined, a leakage test for quality can be quickly made. Set the selector switch to one of the five polarizing voltages available. The working or rated voltage of a condenser is usually printed on the condenser itself. Rotate the leakage switch to the leakage position and observe action of the electron beam indicator tube. A sudden closing and then return to normal shadow angle would indicate a satisfactory condenser. A partially closed eye or a fluttering condition would indicate a leaky condenser. If the eye closes or overlaps, the condenser is shorted. The spring return test switch will automatically discharge the condenser under test so as to completely eliminate DC shock hazard to the serviceman.

Electrolytic condensers frequently have a certain amount of resistance in series with the capacity. To balance the bridge circuit, it is necessary to balance such resistance with resistance in series with the standard consenser (power factor control). As electrolytic condensers are found only in the higher capacity values, the control only functions on the high and extended ranges.

When checking the capacity or quality of electrolytic condensers, it is essential that polarity be observed. The positive terminal of the condenser should be connected to the red test lead or center binding post and the negative condenser terminal to the black test lead or outer condenser binding post.

The power factor is a measure of the energy loss in an imperfect condenser. In filter applications, a higher power fact decreases the effective capacity so that the effective capacity at 20 percent power factor is 98 percent of the measured capacity. At 30 percent power factor, the effective capacity is decreased to 95 percent. While at 50 percent power factor, the effective capacity is decreased to 87 percent of the measured capacity.

When measuring the capacity of electrolytic condensers, the main control as well as the power factor control should both be adjusted for null indication. When both controls are set to the point of balance or null, the capacity reading can be made directly on the calibrated scale and the power factor reading can be taken from the power factor control which is calibrated percentagewise.

The tolerance of many types of condensers is quite wide. While small ceramic and mica condensers used in tuned circuits sometimes have a tolerance of plus or minus 2 percent, condensers for blocking or bypass applications seldom are rated closer than plus or minus 20 percent. Frequently tolerances of minus 50 percent to plus 100 percent are encountered for bypass and filter condensers. Many of the ceramic bypass condensers are specified with a guaranteed minimum capacity.

A significant point of condenser checker operation which would be well worth remembering is that a condenser which will not balance on any of the ranges but allows the eye to open on the low end of the low range is an open condenser. A condenser which allows the eye to open on the high end of the high ranges is a shorted condenser.

CIRCUIT DESCRIPTION

The circuit of the Heathkit Model C-3 Condenser Checker is fundamentally an AC powered bridge circuit formed for both resistive and capacitive measurements. The main control varies the resistance in two arms and third arm (in resistive measurements) consists of either of two resistors one of which is one hundred times larger than the other. Thus the coverage of resistance measurements is obtained. The fourth arm is the unknown resistance.

For capacitive measurements, the main control varies the resistance in two arms, the third arm consists of any one of three known condensers and the fourth arm is the unknown condenser. The high capacity end of the dial is extended by means of an added resistance placed on one side of the main control resistance.

Electrolytic condensers frequently have a certain amount of internal resistance in series with the capacity. To balance the bridge, it is necessary to balance such resistance with resistance in series with the standard condenser (power factor control). As electrolytic condensers are only found in the higher capacity values, the control only functions on the high and extended ranges.

The leakage test places the correct test voltage on the condenser and leakage is indicated by the degree of angle closing in the electron beam indicator tube.

The AC power to the bridge is supplied by a winding on the secondary of the power transformer. Indication of balance or null is by means of a magic eye or electron beam indicator tube. At balance, the eye is open to its maximum point.

For safety of operation, the entire instrument is transformer operated and DC operating voltages are obtained from a half wave rectifier circuit.

Electric Pots and Controls

Electric heating of metal pots has been widely adopted by the printing industry even in those areas where gas is plentiful. Electric heating has many advantages. It is clean, there is never any smoke or fumes; it is, perhaps, safer since there is no open flame or gas to escape and requires no ventilating pipes or flues. Because electric pots are insulated, they radiate much less heat into the room than do pots heated by flame, an important advantage in air-conditioned composing rooms.

METHODS OF ELECTRIC HEATING

There are three types or methods of heating by electricity in wide use today. Simplest, and most familiar to us, is resistance heating, of which the common household toaster is an example. Widely used in certain applications in industry is the second method—induction heating. The third method—also used in industry—is dielectric heating. This last type has also made an appearance in the home appliance field in the form of an oven which can turn out perfectly cooked foods in an unbelieveably short time.

Linotype electric pots are heated by the resistance method.

HOW RESISTANCE HEATING WORKS

When electric current flows through a conductor it meets with resistance and some of the electrical energy is expended in overcoming this resistance. Energy so expended is converted to heat. All conductors offer resistance to current flow but some offer less than others, and we rate conductors as good or poor on this characteristic. Silver is our best known conductor, with copper a close second. Other conductors include aluminum, iron, mercury and nearly all metals.

In most electrical apparatus, resistance is a nuisance, and we select metals of low resistance for our wire and parts that must conduct electricity in order to keep it at a minimum. But if we wanted to build a heating element, we'd use a material, probably an alloy, having high resistance in order to convert a lot of energy in a compact space and so generate a high temperature.

To illustrate, suppose we wish to construct a heating element rated at 1,000 watts for 115 volts. If we were to use No. 18 copper wire, we'd need exactly 2,072 feet of it. This would make a very bulky unit, the wire alone weighing a little over 10 pounds. We could do a little better with aluminum wire of the same size, needing only about 1500 feet and cutting the weight to around two and a half pounds. But, if we use a resistance wire especially developed for heating elements, we will need only 30 feet of the No. 18 size, and we can do even better with this material since it will withstand heat that would melt the copper or aluminum wire. We can use No. 24 wire of which we will need only 7½ feet, weighing less than ½ oz. If we wind this on a special porcelain form, we will have a replica of a heating element commonly found in small reflecting type heaters.

To make a satisfactory heating element the conductor must meet several special requirements. First, and of prime importance, the conductor (usually a wire or flat ribbon) must have high resistance to enable it to convert large amounts of electrical energy in a relatively short length. This enables it to reach a high temperature. It must have good mechanical strength and must not corrode or change electrical characteristics under repeated heating and cooling. It has been found that an alloy of nickel, iron and chromium meets all of these requirements. This material is sold under various trade names, of which "Nichrome" is probably best known to us.

HEATER CONSTRUCTION

Linotype heaters are made in two general types. The older style, known as "envelope" heaters, have a resistance ribbon wound on strips of mica and sealed in sheet steel cases or "envelopes." The later type, "Lino-Therm," consists of a coil of resistance wire encased in a steel tube from which it is insulated with magnesium oxide. For more detailed description of these heaters, see pages 167, 168 and 194 through 196 of "Linotype Machine Principles."

TEMPERATURE CONTROLS

Through the years the electric pot and its controls have gone through a long period of evolution. This has been mostly in improved design and construction of components while basic principles remain the same. From the earliest. crucible temperatures have been regulated by a control alternately turning power on and off to the heaters. With this method full current flows through the heaters until metal temperature reaches a preset limit when the control cuts off current and the crucible begins a period of cooling off which continues until the control again acts to restore current to the heaters and repeat the cycle. Thus the temperature of the crucible is not constant but rises and falls within the limits of the control's range and the capacity of the heaters to maintain temperature during periods when metal is being fed into the pot.

Early electric pots employed a rheostat to control the mouthpiece temperature. By this means, the operator attempted to maintain constant heat by turning the rheostat up or down, much as a housewife adjusts the burners

of her gas range. While this arrangement was used for a long time, the rheostat disappeared with the introduction of "Micro-Therm" controls, which employ a sensing bulb above the mouthpiece to "feel" the heat at this point and operate a switch to control current to the throat and mouth heaters, thus bringing automatic control to the mouthpiece.

The first "Micro-Therm" controls employed no relays, controlling the heater currents directly by micro-switches. Later, a relay was added to the crucible circuit and, still later, on Comet-type pots, a second relay was added to the mouthpiece control circuit. Examples of all these types are to be found in Opubco's composing room.

Micro-Therm controls are basically the same for crucible and mouth and throat heaters. The sensing element consists of a bulb connected by a capillary tube to an expansion bellows. This assembly is filled with a non-volatile fluid. The bulb is placed in the area where temperature is to be controlled—immersed in the crucible for control of crucible heaters and near the mouthpiece in contact with top of crucible, for control of throat and mouth heaters. The bellows responds to changes by expanding as temperature rises and contracting as it falls.

Movement of the bellows is transmitted through a plunger to a micro-switch. The switch is mounted on a swinging lever held by a spring against an adjusting screw which carries a dial outside the case. The arrangement allows for limited adjustment of temperature by turning the dial and provides for over-travel of the plunger, protecting both switch and bellows. The plunger is threaded at one end and provided with a screw and lock nut, by means of which initial temperature settings are made.

DIAGRAMS SHOWING WIRING FOR 220 VOLTS ALTERNATING CURRENT

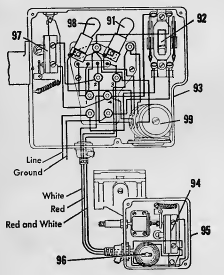


FIGURE 1

Wiring Diagram showing crucible control and mouthpiece control unit connections for 220 volts alternating current.

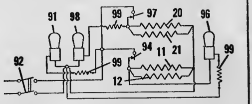


FIGURE 2

Schematic Diagram for 220 volts A.C. pot crucible and mouthpiece control.

View Shows

91. Power Indicating Lamp
98. Crucible Indicating Lamp
100. Crucible Mu-Switch Condenser
92. Power Switch
97. Crucible Mu-Switch
20, 21. Crucible Heaters
96. Mouth and Throat Lamp
101. Mouth and Throat Mu-Switch Condenser
94. Mouth and Throat Mu-Switch
11, 12. Mouth and Throat Heaters

Since all indicating lamps are rated at 110 volts, a resistor is placed in series with each lamp to reduce the voltage from 220 to 110 volts. Except for the wiring to and from the resistors, the connections are the same as for 110 volts alternating current.

In the first lesson, "Working With Schematics," a diagram of a Micro-Therm pot was used to illustrate how a schematic may be broken down into a number of individual circuits. In Fig. 2, the same circuit is reproduced, exactly as printed in Linotype's Instruction Book for the Micro-Therm Electric Pot. Fig. 1 is a pictorial diagram of the same circuit. Identifying numerals have been changed in this figure from those used in the previous lesson.

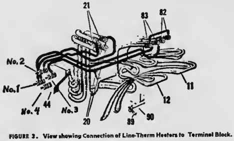


FIGURE 3. View showing Connection of Lino-Therm Heaters to Terminal Block.

Fig. 3 illustrates the arrangement of Lino-Therm heaters and their connection to the terminal block. Note that all Micro-Therm pots have the same arrangement of terminal connections, that is: crucible heaters to No. 1 and No. 2; mouth and throat heaters to No. 1 and No. 3. Comet type pots use the arrangement shown in Fig. 12.

OPERATION REVIEWED

When metal in the crucible is cold and the power switch 92, Fig. 1, is turned to On position, current will flow through the entire circuit. When current is turned on, the three indicating lamps 91, 98 and 99 will immediately light. Power indicating lamp 91 will remain lighted as long as power switch 92 is turned on and power from the line is uninterrupted. Crucible heater indicating lamp 98 will remain lighted only as long as current flows through the crucible heaters. Mouthpiece indicating lamp 99 will remain lighted only as long as current flows through the mouth and throat heaters.

When the metal is cold and power is turned On, electrical current will flow through the crucible heaters and also through the mouth and throat heaters. Both the crucible 97 and mouthpiece 94 micro-switches are always in the On position when the metal is cold. The passage of current through the crucible heater windings will heat the metal in the crucible. As the temperature of metal rises in the crucible, the non-volatile liquid in the expansion bulb will expand and force the plunger adjusting screw against the small swinging lever and when the temperature reaches 535 degrees F, this movement of the expansion bellows will open the micro-switch 97, breaking the heater circuit.

In a similar manner, the mouthpiece control microswitch 94 will "open" when the mouthpiece has reached its proper temperature.

After the crucible micro-switch 97 opens and there is no longer current passing through the crucible heaters, the metal will start to cool. The liquid in the expansion unit will then contract, relieving the pressure on the micro-switch 97 and the micro-switch will snap to the On position again closing the crucible heater circuit. This cycle is repeated as long as the power switch is left in the On position.

The same pattern of heating and cooling is followed by the mouthpiece heaters and their controls.

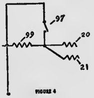


FIGURE 4

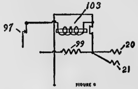


FIGURE 5

POWER RELAY

So far, only one control circuit has been discussed (Fig. 2) which uses micro-switches to control the heater currents directly. This type of control was used on Lino-Therm AC pots with serial numbers below 32,213. Later pots have a power relay inserted in the crucible heater circuit. To see how this is done, compare Fig. 4 with Fig. 5. Fig. 4 is a detail drawn from Fig. 2 showing connections to switch 97. Fig. 5 shows the relay contacts wired in place of the micro-switch. Electrically, the heater circuit is unchanged, but another circuit is added to enable the micro-switch to operate the relay. First pots of this type have the relay mounted in a box under the pot, the power switch is mounted in a box on the mold gear arm. See Figs. 6 and 7. Still later, the relay and power switch were put into a larger box mounted on the mold gear arm. At this time, the power indicating lamp was discontinued and the crucible indicating lamp and the mouth and throat lamp were moved into the new box, termed the crucible temperature control relay and switch box. This circuit is illustrated in Figs. 10 and 11. Somewhere along the line, subsequent to this change, neon glow lamps were substituted for the incandescent type and the evolution of the Micro-Therm pot is completed to the present time. Of course, the large wire-wound resistors used with the incandescent lamps are discontinued. The neon lamps also require resistors, but these are molded in the sockets and are not visible.

ELECTRICAL HEATING TROUBLES

Service interruptions of electrically heated pots fall into two classifications: a, failure of electrical components, and, b, malfunction of mechanical parts of the control. In the following paragraphs are listed the troubles most frequently encountered and suggested tests to determine causes. All the tests to be described may be made with a voltohmmeter and a small neon test lamp.

DIAGRAMS SHOWING WIRING FOR 220 VOLTS ALTERNATING CURRENT

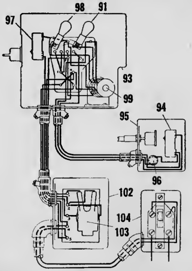


FIGURE 6

Diagram showing crucible and mouthpiece connections for 220 volts A.C.

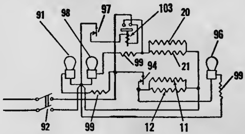


FIGURE 7

Schematic Diagram for 220 volts A.C. pot crucible and mouthpiece control.

View Shows

97. Crucible Mu-Switch
98. Crucible Indicating Lamp
91. Power Indicating Lamp
104. Toggle Switch
99. Power Indicating Lamp Resistor
11, 12. Mouth and Throat Heaters
99. Mouth and Throat Indicating Lamp Resistor
96. Mouth and Throat Indicating Lamp
94. Mouth and Throat Mu-Switch
20, 21. Crucible Heaters
99. Crucible Indicating Lamp Resistor
103. Crucible Relay

DIAGRAMS SHOWING WIRING FOR 220 VOLTS ALTERNATING CURRENT

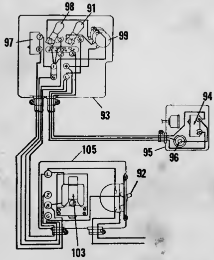


FIGURE 8

Diagram showing crucible and mouthpiece connections for 220 volts A.C.

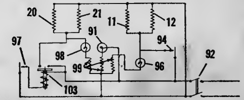


FIGURE 9

Schematic Diagram for 220 volts A.C. pot crucible and mouthpiece control.

View Shows

97. Crucible Mu-Switch
94. Mouth and Throat Mu-Switch
99. Pilot Light Resistors
98. Crucible Pilot Light
91. Main Power Pilot Light
96. Mouth and Throat Pilot Light
103. Crucible Relay
92. Power Switch
20, 21. Crucible Heaters
11, 12. Mouth and Throat Heaters

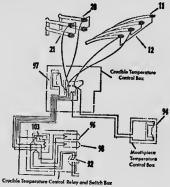


FIGURE 10

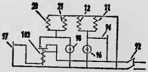


FIGURE 11

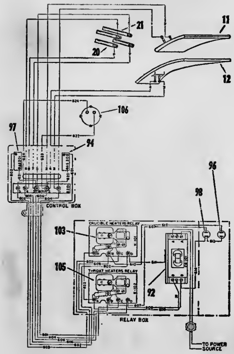


FIGURE 12

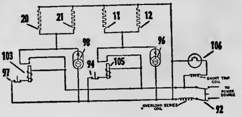


FIGURE 13

POT WILL NOT HEAT UP. Check to see that there is power into the pot and that the power switch is in the On position. If the pot is one of the type which has a power indicating lamp 91, this lamp should be burning if there is current into the control box. If necessary to test to determine if there is power to the pot, refer to the diagram covering the equipment to locate a convenient point to make the test. On all Lino-Therm pots (other than Comet type) notice that terminals 1 and 4 in the crucible temperature control box are connected to the power switch. Using the neon test lamp, touch the test tips to terminals 1 and 4. With the power switch in On position, the lamp should light, and failure to do so would indicate blown fuses, tripped circuit breaker or other interruption of power before reaching the machine. There is also a possibility the power switch itself is at fault and if it is suspected, the line should be tested ahead of the switch.

Assuming there is current through the power switch, note whether crucible indicating lamp 98 is lighted. Referring to wiring diagrams, note that this lamp (and its resistor) is wired in parallel with crucible heaters 20 and 21, and will only fail to light if it or its resistor is burnt out, or the crucible micro-switch fails to close. If no current is passing through the micro-switch there will be no heating effect of the crucible heaters and no current to light lamp 98.

To test whether the micro-switch 97 is operating, press the top of the micro-switch bracket to the left so that the switch operating button is away from the bellows plunger adjusting screw. Then press the button and release it to see whether the crucible indicating lamp goes on. If it does not, the switch should be replaced. This paragraph refers to equipment having no relay.

Occasionally, failure to heat may be traced to a relay not closing. If the equipment being examined has a relay, check to see whether it is closing in response to the micro-switch (after first making sure there is power to the switch). The contact points **should come together** firmly when the relay armature is pulled in. Check condition of the points to make sure they are not too badly burned and pitted.

To see that the relay is receiving current through the switch, place the test tips of the neon test lamp across the coil terminals of the relay, then cause the micro-switch to open and close by moving the switch bracket as described above. The lamp should light when the switch is On. If the relay is receiving current at its terminals, but the armature is not being pulled in, it may indicate an open coil, or the armature may be binding on its hinge pin.

If crucible indicating lamp 98 is lighted and the pot does not heat it is an indication that both crucible heaters are open, or a wire or connection to the heaters is broken. To check for open crucible heaters, turn power switch to the Off position and remove all wires from terminals 1 and 2, (3 and 4 on Comet type) except those leading to the heaters. (Note: When disconnecting wires from electrical apparatus, always tag or mark them so they can be replaced properly.) Now with the ohmmeter set to a low range, test resistance between terminals 1 and 2 (4 and 5 on Comet type). If the meter shows infinite resistance, it indicates open heaters, assuming wires and connections are in good order. Good heaters will test as indicated in the table below.

POT HEATS SLOWLY: This condition can usually be traced to one of three causes. A crucible heater may be open, in which case the other heater will still heat the metal, but slowly. Loose or broken connections to one of the heaters which would have the same effect as one heater being open. The third cause is low voltage.

To test condition of the heaters, proceed as described above. Turn off power switch and remove wires from terminals No. 1 and No. 2 (3 and 4 on Comet type), except the wires leading to heaters. With the ohmmeter set to a low range, test resistance from terminal 1 to terminal 2 (or 3 and 4 on Comet type). Good heaters will show readings comparable to the values shown in the table below. The values here are for two heaters in parallel, at room temperature. Hot heaters will show a higher resistance, possibly as much as 10 percent.

CRUCIBLE HEATERS

110 volts	10.5 ohms
190 volts	27.0 ohms
208 volts	38.0 ohms
220 volts	42.5 ohms

The method of checking the heaters as described above is a quick way to determine if the heaters are at fault since the terminal block in the temperature control box is readily accessible. If the test indicates that one of the heaters may be at fault, it will be necessary to remove the pot cover to test the heaters individually. With the pot jacket cover removed and wires to the heaters disconnected, set the ohmmeter to a low range and test each of the heaters for resistance. Heaters tested individually should read about twice the figure shown in the table above. Allow about 10 percent plus or minus tolerance. An open heater will show infinite resistance.

To test for grounds, touch one test prod to a terminal and the other to a clean unpainted spot on the frame or pot. The meter should read infinite resistance and any significant reading would indicate a ground.

Low voltage is a condition usually associated with an expanding load on old or inadequate wiring. We meet this situation in areas where a rapidly increasing demand has overloaded the power company's distribution system. Or, we may find low voltage when one or more machines are added to existing wiring in a building and the additional load is too much for the line. It would be very unusual to find low voltage on a single machine in a battery, especially if it has been operating satisfactorily in the past and there has been no changes made in the wiring supplying the machine.

A convenient place to check line voltage is at the connections to the power switch. Extreme caution should be exercised because the test must be made with the line "hot." With the switch exposed and the VOM set to test AC, turn the range switch to a voltage range higher than 208 volts. This is the normal line voltage in Opubco's composing room. Test voltage on the line side of the switch. If an inadequate line is suspected, turn the power Off and allow pot to cool down to a point where all heaters come on when power is restored. Now take a voltage reading with power Off, then turn power On and note whether there is a voltage drop. If the voltage falls by more than 2 percent under load, the condition should be reported to the chief machinist.

POT OVERHEATS. Cases of overheating can often be traced to a sticking micro-switch. If not detected before the crucible temperature rises above 600 degrees, there is a probability that the bulb and bellows will be damaged. At the first sign of overheating, the pot should be turned off and the equipment examined to determine the cause of the trouble.

When a micro-switch is damaged by high current, the points become welded together and current will continue through the crucible heaters and action of the expansion bellows will not cause the switch to open, but will continue to press against the switch forcing the upper part of the switch bracket away from the adjusting stud. Current will continue to flow through the heaters until the power switch is opened or until some part of the heater circuit fails, breaking the circuit.

To test the micro-switch, press the top of the switch bracket to the left so that the operating button is away from the bellows plunger adjusting screw. Then press the operating button and release it. The crucible indicating lamp

should go out when the button is pressed, and on when it is released. If the lamp does not go on and off in response pressure on and release of the operating button, the switch is faulty and must be replaced. This refers to equipment having no relay.

If there is a relay, the switch operates the relay and it must respond before the lamp would be lit. Testing the relay was described on pages 14 and 15.

Refer to Fig. 1, and note that the bracket on which micro-switch 97 is mounted is held against the adjusting stud by a spring fastened between the bracket and a screweye in the rear wall of the control box. This spring must be strong enough to overcome the pressure required to open the micro-switch when the bellows plunger presses against the pivot plate. The spring must also allow overthrow protection so that any further expansion of the bellows (after the micro-switch is opened) is permitted. A weak spring would allow too much expansion and thus overheating.

MOUTHPIECE WILL NOT HEAT. The mouth and throat heaters form a circuit independent of the crucible heater and are controlled by the mouthpiece micro-switch 94.

As described under the heading "Pot Will Not Heat Up," make sure that the line current is entering the crucible control box. If the power indicating lamp 91 is lighted, current is entering the control box. If mouthpiece indicating lamp 96 is lighted, it is an indication that the mouthpiece micro-switch 94 is closed and passing current to the mouth and throat heaters. If the mouthpiece lamp is lighted and the mouthpiece will not heat up, both mouth and throat heaters are open, an unusual occurrence since they are connected in parallel and the failure of one heater would still permit the mouthpiece to heat, though slowly.

To test the throat and mouth heaters, turn off power by turning the power switch to the Off position. Remove wires from terminals 1 and 3 (1 and 2 on Comet type pot), except those wires going to the heaters. With a low-reading ohmmeter, test resistance between terminals 1 and 3 (1 and 2 on Comet type pot). An infinite reading here would indicate that both heaters are open, or that a broken wire or loose connection is interrupting the circuit. Good heaters will give readings comparable to the resistance values in the table below.

If the resistance of the heaters is off by more than approximately 10 percent plus or minus of the figures indicated in the table below, it may be that one or both heaters will have to be replaced. The resistances shown on the table below are for both heaters in parallel, and are for when heaters are at room temperature. When heaters are hot, resistance may vary upward by as much as 10 percent, depending upon the temperature.

MOUTH AND THROAT HEATERS

110 volts	19.0 ohms
190 volts	45.0 ohms
208 volts	63.0 ohms
220 volts	70.5 ohms

MOUTH AND THROAT HEATERS (COMET TYPE)

110 volts	9.6 ohms
190 volts	25.0 ohms
208 volts	30.0 ohms
220 volts	38.0 ohms

To test mouth and throat heaters individually, remove pot cover and disconnect wires from the heater terminals. With the ohmmeter set on low range, test the resistance of each heater. Micro-Therm throat and mouth heaters are made in pairs (left and right) each having the same resistance, therefore, tested singly, each heater would show twice the resistance indicated in the table. Comet type heaters are not matched, the lower heater being larger than the upper element. Tested singly, the lower heater will show about two thirds as much resistance as the upper. Tested singly, the heaters should show these values:

180-200 volts, upper heater	63 ohms
200-220 volts, upper heater	75 ohms
180-200 volts, lower heater	42 ohms
200-200 volts, lower heater	50 ohms

MOUTHPIECE GETS TOO HOT. This condition may or may not be a fault of the control. In fact, the mouthpiece is often blamed when overheated molds are at fault. Check the mouthpiece temperature with a surface thermometer if one is available, or use the old trick of rubbing a 6-point slug across the mouthpiece. If tests show heat is too high, see if re-setting adjustments will not bring it into line.

If the mouthpiece temperature is excessive and cannot be brought into line with the controls, it may be an indication of a faulty micro-switch 94 (Fig. 1). The switch may be tested in the manner described under the heading "Pot Overheats" (Page 15).

It may be that the expansion bulb is not in firm contact with the crucible throat so that heat is not being transferred properly. Under this condition, the control will not follow changes in heat closely and overheating may result.

On Comet type pots, check the mouth and throat relay to determine that it is working properly. Tests described for the crucible relay (pp. 14 & 15) would also apply to this relay.

TEMPERATURE OF METAL FLUCTUATES. If the temperature of the metal fluctuates too much, it may be an indication that the bulb and bellows has been damaged by overheating. Damage of this kind makes reaction of the expansion bellows sluggish in re-

sponse to temperature changes. While the bulb and bellows is not an electrical device its function is so directly involved in the operation of the pot controls that a few comments in this discussion seem appropriate.

As explained in an earlier paragraph, the assembly consists of an elongated bulb and expansion bellows joined together by a capillary tube. This assembly is entirely filled with a fluid which is the expansive medium. Any temperature change will cause the fluid to expand or contract, and if the assembly is entirely filled with this fluid, the bellows will faithfully follow each expansion and contraction. If in some way, the metal in the bulb and bellows becomes stretched, the fluid will no longer fill the assembly. Now, when the fluid expands, it will first flow into this empty space which it must fill before exerting pressure on the bellows to cause it to operate the micro-switch. Damage by stretching usually occurs to the bulb and bellows as a result of overheating. The assembly is designed to operate at temperatures of about 535 degrees. At about 600 degrees, the fluid will have expanded the bellows as far as it is designed to go and further expansion of the fluid will stretch the metal, possibly beyond its elastic limit or its ability to return to its original size.

Symptom of a damaged bulb and bellows is wide ranging of the control. Temperature will rise too high before the control cuts off or it will fall too low before turning on. In other words, the range between On and Off will be too wide. The obvious remedy is to replace with a new assembly. In case of damage by overheating, the cause of the overheating should be located and corrected before installing a new bulb and bellows.

In its instruction book for Lino-Therm electric pots, the Linotype Co. gives the following instructions for installing bulb and bellows:

"It is important that the crucible expansion bulb should be ½ in. from the Lino-Therm crucible heaters. This clearance permits the expansion bulb to operate correctly and react to metal temperature changes.

"Placing the expansion bulb closer to the crucible heaters may give slightly closer temperature regulation by a quicker expansion reaction but it is very detrimental to the expansion bulb and may cause permanent injury to this part. This expansion bulb unit is designed and tested for the non-volatile liquid to expand at a predetermined rate. Moving the bulb closer to the heaters will accelerate the expansion of the liquid more than the unit can stand."

Quoting from the same book regarding the mouthpiece bulb and bellows: "Be sure the expansion bulb makes a good close metallic contact with the crucible casting and is located so that it will clear the mold disk as the pot advances. Do not put asbestos around the mouthpiece expansion bulb."

BLOWING OF FUSES, or frequent tripping of the circuit breaker indicates a short or ground in the electrical circuit, which must be cleared up before normal operation can be resumed. The usual cause of shorts and grounds is type metal on the heater terminals and can usually be located by a visual inspection. Grounds also occur due to breakdown of insulation on wires, usually where they pass under the pot cover.

On the Comet pot there is a circuit breaker built into the power switch. This will trip when a short circuit places an overload on the series coil of the circuit breaker. There is also a "Klixon" switch wired to the shunt coil of the circuit breaker, which operates if crucible temperature rises above 600 degrees. The Klixon switch, if defective and in the closed position would cause the circuit breaker to throw out the switch each time the switch is turned to the On position. To check on the Klixon switch action, disconnect the two leads from the Klixon at terminals 2 and 5 in the control box and observe action of the over-temperature switch out of the circuit.

INDEX TO DIAGRAMS

Electric Motors

Motors used in the composing room of the Oklahoman and Times may be divided into two groups. The first includes all motors used to drive the heavier machinery such as Linotypes, conveyors, saws, etc. The second group includes special purpose types such as the synchronous motors used on TTS equipment and the shaded-pole motors on Selecto-spacers.

The first group is the most numerous and nearly all motors in the group are of the same general classification, that is they are all single-phase induction motors. They may be further subdivided into two groups, based on the method of starting, that is, split-phase motors and capacitor motors. To make the explanation short and simple, the induction motor's basic principles will be discussed first, ignoring the method of starting. Later the two starting systems will be taken up individually.

Single-phase Induction Motors

Essentially an induction motor consists of two parts: The rotor and the stator. These are mounted in an enclosure which includes bearings for the rotor shaft and a means of mounting the motor in its place of operation.

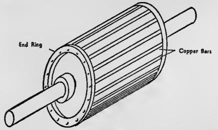


Figure 1

The squirrel-cage rotor is made up of discs of transformer steel, securely mounted on a shaft. Around its circumference are equally spaced slots, each containing a brass or copper bar which extends the length of the rotor and is welded to a ring of the same metal at each end of the laminated steel rotor. The bars and rings together form the winding of the rotor. Some manufacturers now cast the bars and rings of aluminum in the assembled rotor which forms a one-piece "squirrel-cage" embedded in the steel rotor. Fig. 1 is a diagram of a squirrel-cage rotor.

The stator is also made up of steel laminations to form a hollow cylinder of required size. Around the inside of the cylinder are slots which contain the field windings—the running coils and the starting coils. The number of slots and coils will determine the number of magnetic poles and thus the speed of the motor.

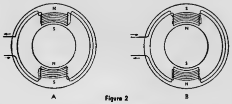


Figure 2

To illustrate how a single-phase induction motor functions, imagine a rotor assembled so that it is free to turn inside a stator, Fig. 2. To simplify the explanation, a two-pole stator is illustrated and the starting coils are omitted. If power is applied to the windings of such an assembly with the rotor at rest, the motor will not start. As illustrated in Fig. 2 at A, when current flowing through the coils magnetizes the stator with N and S poles as shown, current flows in the rotor windings, induced by transformer action, and its magnetic poles are opposite in polarity to those of the stator. As the current reverses in the stator windings, the magnetic poles of the stator will be reversed as shown at B in Fig. 2, but the poles of the rotor will also reverse and there will be no tendency for the rotor to turn.

If, however, the rotor is given a spin as the power is applied, the motor will run and develop its full rated power. It will run equally well in either direction, depending on the direction of the starting spin. As the rotor turns, the conductors of its windings cut magnetic lines of force created by the field coils, which generates a heavy current in the rotor's conductors. The resulting induced magnetic flux in the rotor will have the center line of its poles inclined to the center line of the stator's poles as shown in Fig. 3.

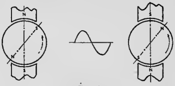


Figure 3

As the rotor picks up speed, the angle at which its poles incline to the stator will decrease and its conductors will cut fewer lines of force, generating less current in the rotor winding and the torque will decrease proportionately. The angle of inclination determines the number of lines of magnetic force cut by the rotor windings. The angle varies inversely as the speed of the rotor, the angle increasing as the speed falls off. The angle can never reach zero for then the motor would be running at synchronous speed, its conductors

would be cutting no lines of force and hence no current would be flowing to generate power to spin the rotor. So, when the motor is running without load, it will accelerate to a speed where its rotor winding develops just enough power to maintain rotation. This is the no-load speed which will be higher than its rated speed but less than synchronous speed.

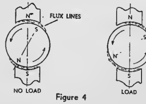


Figure 4

Now if a load is applied, the speed will drop suddenly and the motor will react instantly. The conductors of the rotor will now be cutting more lines of force and consequently generating more power. The rotor will accelerate to the highest speed at which its conductors can generate enough power to carry the load. At this point the power and load will be in balance and speed will remain constant so long as none of the factors vary, thus the motor is self-regulating. Fig. 4 illustrates the motor running under no load and under load.

The speed of a constant speed motor is determined by the frequency of the supply current and the number of poles on its stator. The rotor and stator of a two-pole motor operating on 60-cycle current is illustrated in Fig. 5, at A. The point X on the rotor will travel from the center of the N pole to the center of the S pole while the current is going through one-half cycle, from maximum above the line to maximum below the line. On the alternate half-cycle, the point X will travel from the S back to the N pole. Thus it will be seen that the rotor will make one revolution for each cycle of current. If the current is 60 cycles per second then the speed of the motor will be 60x60 or 3600 rpm.

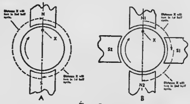


Figure 5

At B in Fig. 5, a four pole stator and rotor is shown. Here, again, the current is 60 cycle. The four stator poles are designated as N1, S1, N2 and S2. Notice that during one half cycle, the point X moves from the center of N1 to the center of S1, and during the alternate half cycle, the point will move from S1 to N2. Thus, in one cycle, the rotor has made one-half revolution. This is only half the speed of the two-pole example or 1800 rpm.

From these two examples, it can readily be seen that if the stator had six poles, the rotor would make one revolution for every three cycles and if the stator had eight poles it would revolve only once in four cycles, for speeds of 1200 and 900 rpm respectively. These are synchronous speeds. The rule for determining the synchronous speed of a motor is: Synchronous speed equals 120 times the frequency divided by number of poles.

However, the induction motor can not run at synchronous speed. As explained above, the rotor must turn something less than 180 electrical degrees for each half cycle. In other words, it must slip as it follows the rotating magnetic field. This slip, or lag, usually amounts to 4 or 5 percent of the synchronous speed which gives rise to the following rule for finding the actual speed of an induction motor: Synchronous speed minus slip equals actual speed. If slip is 4 percent and synchronous speed is 3600 rpm, then actual speed of the motor would be 3600 minus 144 or 3456 rpm, or, as usually stated in round figures, 3450 rpm.

Split-phase Motor

As pointed out above, a single-phase induction motor is not self-starting. There are several methods in use today, of which two are widely used, to impart a starting spin to the rotor. Until the advent of the capacitor motor, the split-phase type practically monopolized the small-motor field. This type has low starting torque, and it cannot be used on machinery which must be started under load; but rather, must be used in applications which allow it to come up to speed before the load is applied. It has good pull-out torque and will keep a machine running even when relatively large loads are placed on it AFTER STARTING. Its speed regulation is good and normally runs at 95 to 96 percent of synchronous speed under load. The starting current is quite heavy, the current consumed while the motor is starting may be three to six times as great as its running current. A split-phase motor of ¼ hp may draw up to 35 amperes while starting. The largest practical size is 1-3 hp.

In order for the motor to be self starting, a starting winding is added to the stator. This winding is placed at 90 electrical degrees from the running coils, in the case of a two-pole stator, this is also 90 mechanical degrees. To explain how the starting winding functions, it will be necessary to recall one of the basic laws of induction: In an inductance, current lags behind voltage by 90 degrees.

The rule, as stated, is for pure inductance, but since all conductors contain some resistance, it is impossible to have pure inductance and the phase difference between current and

voltage is always somewhat less than 90 degrees. The greater the resistance the less the current will lag. This fact is what makes the starting coils of the split-phase motor effective. The running coils are wound of many turns of heavy wire and have low resistance and high inductance. The starting coils, on the other hand, contain fewer turns of smaller wire which give them less inductance and more resistance than the running coils. The result is that current reaches a peak in the starting coils before it does in the running coils. The difference is probably no more than 30 electrical degrees, but it is enough to give the effect of a moving magnetic pole and this in turn causes a torque in the rotor. The diagram in Fig. 6 shows the relationship of starting coils to running coils.

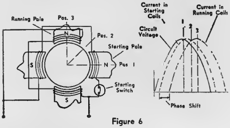


Figure 6

Notice that the starting winding is connected to place its N pole midway between the N and S poles of the running field and its S pole is opposite at a point midway between the S and N poles of the running field. Now, when power is applied to the motor, current will lag behind voltage in the running coils by nearly 90 degrees because this winding is highly inductive. Current in the starting coils will also lag behind voltage, but this winding is much less inductive than the running coils and the lag will be less. Looking at the diagram in Fig. 6, at the instant current reaches its peak in the starting winding, current is still building in the running coils. At this instant the center of magnetic flux will be at Pos. 1. As current decreases in the starting windings, it will be increasing in the running coils and at one instant the two currents will be equal. At that instant there will be a composite pole formed by the combined flux of the two windings, centered at Pos. 2. While current further declines in the starting circuit it will have reached its peak in the running winding and the N pole will be centered at Pos. 3. Thus it can be seen that the magnetic field has moved 90 degrees in one-half cycle of current. This effect of moving magnetic poles will attract the rotor and impart the necessary spin to start the motor.

If the leads to the starting winding be interchanged, the polarity of the starting poles will be reversed with respect to the running poles. Thus the starting pole shown as N in Fig. 6 will become S and the pole shown as S will become N. Since the leads to the running winding remain unchanged, the running poles will have the same polarity shown in Fig. 6. The result of such a change would be to reverse the direction of rotation of the magnetic field and give the rotor a starting spin in a direction opposite from that imparted before the change. Thus the motor will run in reverse rotation. The same result could be achieved by reversing the leads to the running coils while leaving the starting leads unchanged.

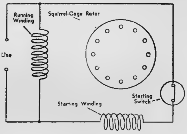


Figure 7

Some means of disconnecting the starting coils after the motor is started is necessary and this is done automatically by a centrifugal switch mounted within the motor housing. The switch operates to disconnect the starting coils when rotation reaches 75 to 80 percent of full speed. A schematic diagram showing the internal connections of a split-phase motor is shown in Fig. 7.

The starting winding of the split-phase motor will heat very rapidly and action of the starting switch must be positive and unfailing. Anything which acts to prolong current flow through the starting coils may cause the coils to be burned out. Such failure could be brought about by trying to start the motor under load or by a defective centrifugal device failing to open the circuit.

Capacitor Motors

Capacitor motors are an improvement over the split-phase type which they are rapidly replacing. They have much greater starting torque than the split-phase type, while drawing less current from the line.

Basically, the capacitor-start motor differs from the split-phase type only in the method of creating a revolving magnetic flux to start the motor. Comparison of the wiring diagram for a capacitor-start motor with one for a split-phase type shows the only difference to be a capacitor inserted in the starting circuit (Fig. 7 and Fig. 8). Physically the starting coils for the capacitor motor are proportioned differently and a split-phase motor could not be con-

verted to capacitor-start merely by adding a condenser.

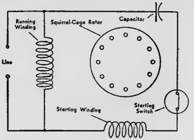


Figure 8

Capacitor starting works because of two basic laws of electricity: In a capacitor, current leads voltage by 90 degrees; in inductance, current lags voltage by 90 degrees. While it is impossible to have a circuit containing only pure capacitance or pure inductance, the combination in the capacitor-start motor produces a phase difference between starting and running windings of approximately 90 electrical degrees. Fig. 9.

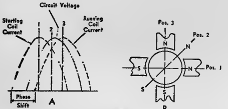


Figure 9

As shown in the wiring diagram in Fig. 8, the running coils are connected in the usual manner, while the capacitor is wired in series with the starting coil and centrifugal switch. In operation, the capacitor will draw current through the starting coil in advance of peak voltage, while the running coils, being largely inductive, will not receive peak current until the voltage peak has passed. The result is that current through the two sets of coils will be approximately 90 degrees out of phase and the magnetic field will rotate very much as the field of a two-phase motor. This serves to give the motor a high starting torque while drawing a comparatively small current from the line. The centrifugal switch disconnects the starting coils and capacitor from the line when motor speed reaches 75 to 80 percent of synchronism.

As with the split-phase motor, the direction of rotation may be reversed by interchanging the leads to either starting or running windings.

The fact that the rotating field produced by the capacitor so nearly duplicates that of a two-phase motor, has led to a further development of the capacitor motor. This is called a two-value capacitor motor. This type has two capacitors, one of which is in the circuit all the time the motor is running. At starting, both capacitors are connected in parallel and the centrifugal switch disconnects one, leaving the other in series with one set of coils. Thus, the addition of a condenser converts the single-phase motor to a two-phase machine.

Shaded-Pole Motor

The shaded-pole motor is a form of induction motor made only in small sizes. Its very low starting torque limits its use to fans and other light machinery requiring only small power to start. It has high slip and its speed regulation is poor. This type has made its appearance in the composing room recently as the power in the Selecto-spacer.

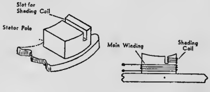


Figure 10

The stator is of laminated construction but differs greatly from the stators of the motors previously discussed. In this motor the field coils are wound on projections or poles extending inwardly from the outer ring of the stator. Each pole has a slot cut across its face in which the shading coil is wound. The shading coil may consist of only a single closed loop of copper ribbon. This construction is shown in Fig. 10.

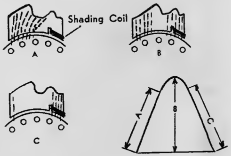


Figure 11

The shaded-pole motor has a high resistance squirrel-cage rotor very much like the ones found in split-phase and capacitor motors. Its high resistance conductors give it somewhat greater starting torque but also increases its slip. Speed of this type of motor may vary

greatly with changes in load or line voltage.

There are no starting coils and no centrifugal switch. The shaded-pole motor starts and runs because the action of the shading coil causes the magnetic flux to move across the pole face, creating a revolving field of sorts. How it does this can be readily understood by studying the diagram in Fig. 11. Notice that as the field current increases from zero toward a maximum at 90 degrees, expanding lines of force will cut the shading coil in which a voltage will be induced which will oppose the inducing voltage. This interferes with an even distribution of the magnetic flux and most of the lines of force will be concentrated in the unshaded portion of the pole (Position A), When field current reaches its peak at 90 degrees, lines of force resulting from this current will reach the limit of their outward expansion, and magnetic flux will be at maximum. As lines of force come to a stand-still, no voltage will be induced in the shading coil and magnetic flux will be evenly distributed across the face of the pole (Position B). As the current in the field coil decreases toward zero at 180 degrees, its lines of force will collapse. As they do so, they will cut the shading coil, inducing a current which will tend to support the collapsing field. Magnetic flux resulting from current in the shading coil will now be at a maximum, and most of the lines of force will now be concentrated in this portion of the stator pole (Position C). From the diagram it can be seen that in 180 electrical degrees a magnetic field of N polarity has shifted across the face of the stator pole. On the alternate half cycle (from 180 to 360 degrees) action of the field coil will be reversed and a S pole will be induced. The action of the shading coil will be the same as before and the magnetic field will shift from left to right or toward the shading coil.

Movement of the magnetic field from left to right will produce a torque in the rotor sufficient to start and drive light loads. The rotor will always turn toward the shaded portion of the stator pole.

Synchronous Motors

So far, this discussion has taken up three examples of induction motors. All have had one common feature: they operate by virtue of a current induced in the rotor. Because of this, they must run at less than synchronous speed. In large synchronous motors this limitation is overcome by winding the rotor with wire and feeding a DC to this winding from an external source. This motor will run at synchronous speed and furnish its full rated power. Such an arrangement is expensive and is only feasible in large installations. Permanent magnet type rotors have been used in miniature motors but the power developed is very small and their use has been limited to clocks and other applications where rate of turning is of prime importance and only very little power is required to maintain operation.

One type of small motor which operates at synchronous speed and furnishes a useful amount of power is the "reluctance-run" motor. Its principle of operation is based on the magnetic law of reluctance. Reluctance in magnetism may be compared to resistance in electricity. Magnetic materials, such as iron, have low reluctance while air, for example, has high reluctance. Magnetic lines of force tend to follow paths of least reluctance. It should also be recalled that magnetic lines of force tend to become as short as possible.

The reluctance-run motor used to power Teletypesetter equipment has a four-pole stator similar to that of a split-phase motor. As a matter of fact, its starting winding is of the inherent resistive type and functions exactly as does the split-phase type.

The rotor has no windings of any kind. Its four salient-poles project outward from the rotor and the assembly includes a centrifugal device to operate the starting switch.

When power is applied to this motor, current in the starting winding and the running coils will act to create a revolving magnetic field. This will start the rotor spinning and at about 75 percent of synchronous speed the starting winding will be disconnected by the centrifugal switch. When this happens, there will be a tendency for the rotor to slip backward but to do so it must lengthen the lines of force between stator and rotor poles. These lines of force will offer powerful resistance to this tendency and will quickly overcome it. The speed will be accelerated to synchronism and will lock in step with the revolving magnetic field.

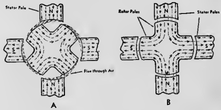


Figure 12

Fig. 12 is a diagram illustrating operating conditions of a reluctance-run motor. At A, the flux lines are drawn expanded as they would be when the motor is starting up. Air has high reluctance while the iron of the rotor has very low reluctance. Lines of force from the stator poles reach out to the rotor poles to gain the easy paths through the rotor. Where these lines pass through iron their paths are as short as possible but are extended through the air. They will shorten themselves in this area by drawing the rotor poles toward

those of the stator. This action is very fast and the rotor will quickly reach synchronous speed. Flux paths through air will now be very short. The shortest possible paths through air would be achieved if the rotor poles were exactly centered with the stator poles as shown at B, but if this position were reached at the instant of highest flux the poles would lock and rotation would cease. Under actual running conditions, the rotor poles never quite reach this position but do maintain exactly 90 degrees of rotation for each cycle of current, giving synchronous speed.

Trouble Shooting

Aside from regular lubrication at scheduled intervals and occasional wiping of oil and dirt from the case, motors require remarkably little attention. However, there will be failures and the machinist will have to decide whether to repair or send the motor outside. Usually troubles of a purely mechanical nature can be handled in the shop while damaged or defective windings call for the services of a motor repair shop. Some of the more common causes of motor breakdown are discussed in the following paragraphs.

Bearings

Before the motor is dismantled, it may be clamped in a vise or otherwise secured to the bench so that the bearings may be tested for wear. The rear bearing may be tested by lifting or prying on the shaft. In a sleeve-type bearing, a small amount of play is permissible but must not exceed a few thousandths of an inch. If the motor has ball bearings, the slightest indication of wear calls for replacement of the bearing. The front bearing (opposite the pulley or gear end) may be covered by a cap. Removing this cap will usually permit testing the bearing by inserting a screwdriver under the end of the shaft and prying up to determine the amount of wear.

End play may also be checked at this time. Some end play is necessary with sleeve bearings, the amount varying with size and type. For a 1-3 hp motor the shaft should have about .015 to .030 inch end clearance. Too little end play may cause heating and bearing wear, while too much clearance makes for noisy running and can cause faulty operation of some types of starting switch. End play may be adjusted by use of fibre washers when the motor is being re-assembled.

When the motor is torn down, the end-shields should be cleaned and all old oil or grease cleaned out. If new bearings (sleeve type) are to be installed, they should be inserted in place in the end-shields, then reamed to fit the shaft. A running clearance of .002-inch is average for motors of $\frac{1}{4}$ to 1-3 hp. The shaft is examined to be sure it is in good condition. A rough shaft will quickly ruin a new bearing. A few drops of the correct grade of oil should be applied to the shaft and bearing when assembling the motor. If there are oil reservoirs, these usually are not filled until the motor is installed for operation as the oil is bound to be spilled when handling the motor.

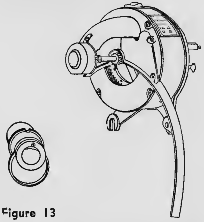


Figure 13

The front bearing of the Linotype geared motor is a ring-oiled sleeve bearing illustrated in Fig. 13. (Note that contrary to standard practice, Linotype calls this the rear bearing.) There is a rectangular window or slot cut in the bearing with connecting grooves to distribute oil over the inside surface. Surrounding the bearing, and resting on the shaft through the slot is a brass ring. The lower circumference of the ring dips into the oil in the reservoir below. Rotation of the shaft causes the ring to turn carrying a constant supply of oil to the shaft and bearing. When installing this bearing, care must be exercised to prevent damage to the ring. Anything which prevents its free turning will prevent oil reaching the bearing even with a full reservoir.

If the motor has ball bearings of the open type, they may be cleaned by soaking and washing in a good clean solvent then blowing dry with compressed air. The bearing may be packed with the grease used for lubricating motor bearings. This should not be done until the motor is being reassembled. In the meantime the bearings should be kept clean and dry. If the bearings are of the shielded type, there is no provision for repacking and no lubrication is required for the life of the bearing.

While on the subject of ball bearings it should be mentioned that excessive grease can cause trouble. They should be greased sparingly and only at times scheduled. On some motors with ball bearings, there is a grease fitting or screw plug for inserting grease on the top of the bearing housing. Near the bottom will be found another screw plug which is the relief plug.

When lubricating this bearing, remove the relief plug, then start the motor. Add grease slowly with a hand gun until grease begins to flow out of the relief hole. Continue to add grease until the grease coming out of the hole is clean. Let the motor continue to run a few minutes before replacing the relief plug. This method usually eliminates most of the old oil and keeps pressure from forcing oil through to the inside of the motor where it may foul the starting switch.

Starting Switch

Starting switches used on motors on composing room equipment fall into two classes. One is the type shown in Fig. 14, which is used

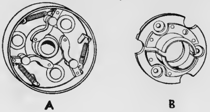


Figure 14

on Linotype geared motors. This switch consists of a split ring (B) mounted on the bearing housing of the motor, and a disk (A) mounted on the rotor shaft, carrying three spring-loaded brass fingers. When the motor is at rest or running at low speed, at least one of these fingers will bridge one of the gaps in the split ring. One half of the split ring is connected to the starting winding and the other half is connected to one side of the supply line. So long as one of the fingers touch both sections of the ring, the starting winding will be connected to the line and current will flow through it. When the rotor reaches a speed where centrifugal force, acting on the fingers, overcomes the tension of the springs, the fingers will lift off the ring and disconnect the starting winding. So long as sufficient speed is maintained, the fingers will be held clear of the ring and the starting circuit will remain open. The device is so simple that any defect would be apparent on examination, with one possible exception. The disk carrying the brass fingers is insulated from the hub at the rivets where the two parts are fastened together. If this insulation fails, the motor will be grounded whenever one or more of the fingers are in contact with the ring.

There is a second class of starting switches which are applied to all but the geared motor. Details vary from one make to another, but all are similar in operating principle and only one will be described here.

The switch consists of two parts, a centrifugal device mounted on the rotor shaft and a switch mounted on the inside of the end-shield. The centrifugal device consists of L shaped weights pivoted on a frame with springs arranged to hold them in a closed position. One end of each weight engages a groove at the end of a sleeve which slides fore and aft along the rotor shaft. The end of the sleeve near the switch terminates in a flange or disk.

Inside the end-shield the switch is mounted in a position which allows the flange on the centrifugal device to press the contacts together when the motor is at rest. When power is applied and the rotor begins to turn, the flange will still hold the contacts together. However, as speed approaches full running speed, centrifugal force will overcome the pull of the springs and cause the weights to fly outward, drawing the sliding sleeve along the shaft toward the rotor. This pulls the flange away from the contact spring allowing the switch to open.

With some switches of this type, excessive end play may prevent the flange from pressing the contacts together. This could also result from too many spacing washers on that end of the shaft.

If there is trouble in the starting switch, careful examination will usually discover it, and the nature of the fault will determine the steps necessary to correct it. Generally, if all parts are clean and in good order and if the contacts "make" correctly, the switch will function satisfactorily.

Stator Windings

Visual examination is frequently all that is needed to determine that a winding is no longer usable. Overheating is the most common cause of damaged windings and the starting coils most frequently suffer damage. Coils are wound of enameled magnet wire and when in good condition are characterized by the smooth glossy appearance of the wire. Excessive heat will dull the gloss and cause the enamel to crack and flake off the wire. This condition dictates that the motor be rewound.

To test for shorts, grounds and open coils, an ohmmeter may be used. Open windings will be indicated by infinite resistance when the ohmmeter is connected across the leads to the coil. Grounds are indicated by resistance readings of less than one megohm between winding and stator laminations. A short is indicated by a low resistance reading between windings and frame or other components. In testing for open starting coils the possibility of an open starting switch should be eliminated by testing the switch first.

Capacitors

The capacitor is usually mounted in a small case attached to the motor housing and is easily removed. Most capacitors will have their

rated capacity and working voltage printed or stamped on them and they can easily be tested on the capacity bridge. Capacitors testing less than 80 percent of their rated capacity may cause poor starting torque and should be replaced.

Miscellaneous

A factor which contributes to bearing wear is belt tension. The fact that a belt is pulling a load causes it to pull the shaft in the direction of the driven pulley, a condition that is normal and will cause only normal wear of bearing and shaft, which will be proportionate to the load. A belt that is too tight places an additional load on the bearings of the motor as well as those of the driven shaft, and this added load may well be greater than the normal load. The belt should be run with just enough tension to pull the load without slippage, which should allow some slack. Because V-belts get their traction from contact of their angular sides with the sides of the pulley groove, they may be run quite loose as compared to flat belts. Belt tension is important and should be kept in mind when installing new belts or adjusting old ones.

Noisy running may be caused by loose or worn pulleys, improperly meshed gears, excessive end play or a worn or bent shaft. Defective rubber mountings can also cause noise. The remedy for any of these is obvious once they are discovered.

A bent shaft is a rarity and may not be so easy to find. If badly sprung, of course, the motor will not run, but it may be just bad enough to cause noise, vibration and bearing wear. The shaft may be tested by mounting between lathe centers and testing for straightness with a dial indicator. Do NOT attempt to straighten the shaft in the lathe. If the motor has provision for easy replacement, a new shaft will solve the problem. If it must be straightened, it should be sent to a shop specializing in that kind of work.

Older motors may have squirrel-cage rotors with soldered conductors instead of the welded or cast construction currently used. Vibration sometimes causes cracks in the solder creating high-resistance joints. The condition can cause poor starting torque and noisy running due to excessive slip.

Most motors are rated on a "40-degree Centigrade Continuous" basis. This means that a motor so rated and running continuously while delivering the horsepower stamped on its nameplate, will not rise more than 40 degrees C. above room temperature. A rise of 40 degrees C. is the same as a rise of 72 degrees F., so that on a hot summer day in a room where temperature is already 100 degrees F. the motor may be as hot as 172 degrees F. That is only 40 degrees F. below the temperature of boiling water and of course will feel decidedly hot to the hand, but the motor is safe.

The Underwriters Laboratories Code places definite limits on maximum size of fuse permitted in branch circuits serving a motor of any given amperage as stamped on the nameplate of the motor. The maximum averages about three times the normal amperage of the motor as shown in the table below which is for AC single-phase motors:

Motor Amperes	Max. Fuse Size in Amps.
1 to 5	15
6	20
7 to 8	25
9 to 10	30
11	35
12 to 13	40
14 to 15	45

Fuses used with motors should be of the time-lag variety which will carry the heavy starting current without blowing and still give some protection from overload. Far better protection, however, can be obtained by using one of the many motor controllers available. Many of these combine the function of a switch with that of a thermal cutout, affording convenience and protection in the one device.

This paper has barely touched some of the many phases of the subject. To anyone interested in more complete coverage, the following books are recommended reading: "Small Noncommutator Motors" by McDougal and Graham; "Basic Fractional Horsepower Motors and Repair" by Gerald Schweitzer. The reader is also referred to "Basic Electricity" Vol. 3, pages 1 through 17, pages 61 to 64 and pages 107 through 112; also Vol. 5, pages 97 through 106.

INDEX TO DIAGRAMS

Relays and Solenoids

The magnetic relay and the solenoid are both forms of electromagnets. An electromagnet is essentially a coil of wire surrounding an iron core.

Current passing through a wire generates a magnetic field around the wire. By forming the wire into a coil of many loops the magnetic field is greatly increased. This increased field strength is due to the field of each loop being in series with the fields of the other loops. This causes the lines of flux to flow through the inside of the coil of wire, out the end of the coil, then return on the outside of the coil to flow through the inside of the coil again. As long as current continues to flow through the coil wire these lines of force continue to flow in this manner. The magnetic field is much stronger on the inside of the coil than on the outside. This is caused by the lines of force being able to fan out the full 360 degrees on the outside of the coil but are much more concentrated when passing inside the coil.

Soft iron offers less opposition to magnetic lines of force than does air. So if the wire is coiled around an iron core a much denser or stronger field is generated. Also, soft iron is a poor retainer of magnetism. In other words, the iron core serves two purposes. It is a good conductor of magnetic lines of force and it retains very little residual magnetism when current ceases to flow. The strength of the magnetic field is mainly controlled by two things: (1) the number of loops of wire in the coil and (2) the amount of current passing through the wire.

By adding an armature adjacent to one end of the core of the electromagnet, we have the type of magnet used on some of our equipment in the Composing Room. The armature is merely a movable piece of ferrous metal with low opposition to the flow of magnetic lines of force. Now when a current is passed through the coil of wire the magnetic lines of force are concentrated as they pass through the armature much as they are in the coil core. The part of the armature nearest the end of the coil core will be of opposite polarity to the core end. Because opposite magnetic poles attract, the armature will be pulled to the core. (See pp. 51-55, Vol. 1, Basic Electricity.) A spring attached to the armature can move it away from the core when current ceases to flow. We utilize this movable armature of an electromagnet on some of our equipment in the OPUBCO Composing Room.

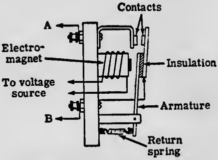
The selector shaft clutch of the teletypesetter operating unit is disengaged by an electromagnet. The TTS perforator uses a magnet to unlatch the stop lever each time a key is struck. The page printer, reperforator and transmitter also use electromagnets.

RELAYS

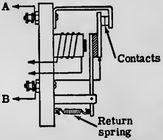
There are other types of relays but we will discuss only the magnetic (contactor) relay.

As was stated earlier a relay is actually an electromagnet. The relay has an armature attached to it. Movement of this armature moves electrical contacts.

A relay may have only one set of contacts



Relay with Normally Open Contacts



Relay with Normally Closed Contacts

Figure 1

as in Fig. 1 or it may have many sets of contacts. The contacts can be normally open, normally closed or some of each. They may also be constructed as single throw or double throw contacts.

A relay can be defined as an electrically controlled switch. However, the relay has more intricate applications than a simple electrical switch. For instance, a small current can be used to control a large current. An example of this application is used on the pot controls of the Comet type pot. Closing of a micro switch sends a relatively light current through the coil of a relay closing contacts through which the heavy current flows to the heating elements. Thus we have one circuit controlling another circuit.

The classified rule inserter uses relays to receive, hold and pass on signals from the tape so that rules will be inserted in the proper places. These relay contacts help control the circuit to their own coils as well as acting as switches in other circuits. These rule inserter relays are its memory circuit or system.

The electrical safeties on the Model 30 and Model 36 Linotypes use the relay to energize a solenoid so that magazines may be elevated or lowered.

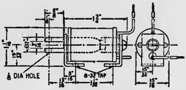
All of our electrically-controlled quadders use relays to control the sequence of operations and to select the proper function.

The selecto-spacer uses relays to receive and hold a signal for thin or nut spaces to be inserted with the spacebands in a line.

The Photon Cleantape makes use of relays more extensively than our other composing room equipment. It has approximately 175 relays. These have up to 18 contacts mounted on them. Some of these relays help control 12 different circuits.

SOLENOIDS

The solenoid is an electromagnet with a movable core. The electromagnet and the relay have cores that are fixed in relation to the coil. The solenoid has a core that can be moved into and out of the center of the core. The coil of a solenoid is wound around a hollow tube of brass or some other material that offers high reluctance to magnetic lines of force. The iron core is positioned inside this hollow tube. The tube acts as a guide for the movable core and will



Solenoid of the type used with the Electronic Mat Detector to lock down the assembling elevator.

not be polarized as is the core. If the core is pulled a short distance out of one end of the coil and current then applied to the coil, the core will be pulled into the coil due to the magnetic field inside the coil and through the core.

Connecting a lever or such to the end of the core will produce a mechanical function when the core is pulled into the coil. A spring is used to retract the core after current ceases to flow. The relay is used to control electrical functions but the solenoid is used almost exclusively to perform a mechanical action. In other words, a mechanical action is controlled electrically by use of a solenoid.

Like relays, solenoids vary greatly both as to physical and electrical properties. The coil of either may be partly or completely surrounded by an iron case to intensify the magnetic field. Either can have the coil wound to operate on AC or DC in many different voltage ratings. Some are constructed for intermittent operation only while others are made for continuous duty.

Some of the uses of solenoids in our Composing Room are as follows:

The Star Selectromatic quadder—To move the pump stop arm from beneath the pump arm; to operate the justification lockout mechanism; to engage the rack(s) to determine the correct quadder function.

The electrically controlled Hydraquadder—To kick up any depressed push buttons when tape is run.

The Selecto-Spacer—To unlatch the selector levers; to raise the thin space and en space keyboard key weights.

Electrical Safeties, Model 30 and 36—To unlatch the elevating shaft to permit magazine shifting.

Electronic Mat Detector—To lock down the assembling elevator.

Monotype—To regulate the flow of gas to the pot burners.

ROTARY SOLENOID

The rotary solenoid has a disc attached to the protruding end of the core. This disc is referred to as an armature. Between this disc and the coil casing steel balls are placed in inclined slots. When the coil is energized and the core moves inward, the armature rotates.

By attaching a spring, post or lever to this armature the rotary action can be utilized to perform a mechanical function. We use rotary solenoids as follows: To open the pump stop on machines equipped with Hydraquadders; to move a plunger and roller into the path of a cam so that a rule will be dropped by the classified rule inserter; to regulate the flow of hydraulic fluid on electrically controlled Hydraquadders; as a last mat kicker on the Comets; to operate the shift and unshift mechanism on the TTS perforator.

GENERAL

Current should not be run through a solenoid coil when the core is completely removed. The greater reluctance of air over iron will generate additional heat which can damage the coil winding. The core of a solenoid should be kept clean so that it can move freely.

Relay contacts vary widely in shape, size, etc. Contact points are adjusted so they are

completely separated when open and so they make a good contact when closed. The gap between contact points varies according to the relay and its use. For instance, the contacts on a Comet type pot control carry about 7 amperes of current at over 200 volts while a memory relay contact for the rule inserter carries less than $\frac{1}{2}$ ampere at 24 volts. The contacts on the pot relay are many times heavier than those of the rule inserter relay. The gap between the contact points is far greater on the pot relay. Relay contact points should be cleaned periodically with soft paper or cloth dampened with a cleaning fluid such as carbon tetrachloride. If necessary a buffer may be used to smooth the contact point surfaces. Ordinarily a file should never be used on contact points. Many contacts are made of or are coated with a metal such as silver for better conduction. Filing will remove this coating. Some contacts will become coated with an oxide during operation. Usually, this oxide is a very good conductor and does not need to be removed.

When adjusting contacts they should never be sharply bent. The bend should be a gradual one.

Transformers and Rectifiers

The transformer has been defined as a device for transferring electrical energy from one circuit to another. Its design and operation is based on the principles of inductance. Basically, a transformer consists of two or more coils of wire enclosing an iron core. The coils are electrically insulated from each other. One of them will be connected to the supply line and will be the exciting coil or primary. The other coil or coils will be the secondary and will be connected to the load. The iron core serves to couple the coils magnetically. Fig. 1

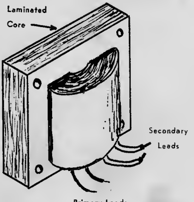


Fig. 1

If an alternating current is sent through the primary coil it will generate a pulsating magnetic flux in the iron core which will alternate in step with the primary current. Lines of force from this magnetic field, cutting the conductors of the secondary coil, will generate a voltage in this winding and current will flow, provided the secondary is connected to a load.

Like all inductive devices, transformers are designed to do specific jobs. They must be connected to supply lines of voltage and frequency for which they are designed. The load must not exceed the power rating.

Transformers usually are employed to change voltage. For example, a device designed to operate on 24 volts 60 cycle AC may be connected to 115-volt power lines of the same frequency through the medium of a transformer. If the primary is wound for it, the transformer could be connected to a 230-volt line. Some transformers have two primary windings of identical size. Connecting the two in parallel allows the device to be connected to 115-volt lines while connecting them in series permits use on 230-volt lines.

There is a definite relationship between primary and secondary voltages based on the ratio of number of turns in primary to turns

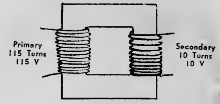


Fig. 2

in secondary. To take an example, suppose a transformer has 115 turns of wire in its primary coil and is connected to a 115-volt line.* The voltage drop across the primary will be 115 volts and this drop will be evenly distributed throughout the primary. Since there are 115 turns of wire in the primary, each turn will receive 1 volt. The magnetic field resulting from this current, will be uniform throughout the area of the coils and a voltage will be generated in each turn of the secondary coil equal to the voltage per turn in the primary, or 1 volt per turn. Now if the secondary has 10 turns the output voltage will be 10 volts. If the secondary has 115 turns, the output will be 115 volts and if it contains 500 turns the output will be 500 volts.

Transformers are sometimes classified according to ratio of primary voltage to secondary voltage. If the output voltage is less than the primary voltage, the device is called a step-down transformer; if the secondary voltage is higher than the input, it is a step-up transformer. Where input and output voltages are equal, the device is an isolation transformer. Some transformers combine the functions of more than one of the above classifications.

While there is a small loss of energy in the form of heat, the loss is so small that it may be ignored in this discussion. So it may be stated that power input equals power output. In the example illustrated in Fig. 2, suppose the load current is 20 amperes. The output voltage is 10 volts, then output power is equal to 20 times 10 or 200 volt-amperes. If we disregard losses, the primary power will also equal 200 volt-amps. Since primary voltage is 115 volts, primary current is equal to 200 divided by 115 or 1.739 amps.

So long as it is operating within its capacity, the transformer will draw from the line only as much power as its load requires and it is self-regulating. If the transformer is overloaded, its primary will draw from the line more

* NOTE: Number of primary turns and secondary turns given in this example are purely arbitrary figures. In actual transformers, the number of turns in their windings are affected by several factors and vary accordingly. However, the relationship between primary and secondary as to turns, voltage and current holds true for all transformers.

power than its core can pass along to the secondary and this additional power will be converted to heat. If prolonged, this heat may damage the windings and the transformer may be ruined.

Some accessory devices used in the composing room of the Oklahoman and Times operate on AC at reduced voltages. There is the machinists' call system which is operated at 24 volts AC and is connected to the line through a transformer. The TTS conveyor system has electrically controlled discharge gates and signals operated on 24 volts AC supplied by a transformer.

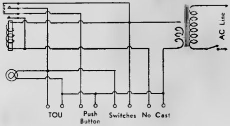


Fig. 3

An example of a practical application of a transformer is illustrated in Fig. 3. This is a circuit diagram of the electrical safeties applied to a Model 31 linotype, No. N1. The transformer is connected to the supply line through a small toggle switch. Its secondary supplies power for a solenoid on the Teletypesetter operating unit (TOU), a control relay and a signal lamp. The secondary output is 6 volts. Switches are arranged to operate the relay if a line fails to cast or if the assembler delivery belt is stopped. Additional switches could be added (in parallel connection) to activate the solenoid when the distributor stops or when a jam occurs under the assembler chute finger. When the relay is energized, by the no-cast switches, one pair of its contacts will serve to maintain current through the relay coil until the push button is pressed to break its connection to the transformer. The second pair of contacts close the circuit to the solenoid on the TOU. This solenoid acts to disengage the clutch on the TOU and so long as it is energized, the unit will not run. These contacts also control the signal lamp. The switch on the assembler belt shifter and any additional switches are connected in parallel with the second pair of relay contacts.

Dry Metal Rectifiers

While the examples cited use AC at reduced voltages, other pieces of equipment require direct current for their operation. Before such equipment can be connected to power lines, some means of converting the AC from such lines to a direct current must be provided. This can be done with rectifiers.

The fact that dry metal rectifiers are compact, sturdy and have no moving parts, make them ideal for most applications in the composing room. Such rectifiers work because of the curious fact that certain combinations of metallic materials offer greater resistance to current flow in one direction than to current flowing in the opposite direction. Two commonly used combinations are copper with copper oxide and iron with selenium. Copper-oxide rectifiers are formed of disks or washers of copper, coated on one side with copper oxide. A number of such disks are clamped together by passing a bolt through the hole in their centers. The individual elements are connected in combinations of series and parallel connections to give various voltage and current ratings. The selenium rectifier is very similar to the copper-oxide type, but is formed from disks to iron coated on one side with selenium. Lately rectifiers employing silicon have come into wide use.

A perfect rectifier would offer zero resistance to current flow in one direction and have infinite resistance to current flowing in the opposite direction. Dry metal rectifiers are not perfect, but their resistance in one direction is many times that offered to current flow in the opposite direction. This resistance can be measured with an ohmmeter. To check a dry metal rectifier, test its resistance with test leads connected to its terminals, then interchange the test leads and again read the resistance. If one reading is at least 10 times the other reading, the rectifier is good.

Figure 4 is an elementary rectifier circuit giving half-wave rectification. The graph at the left represents two cycles of alternating current. During the positive (above the line) half

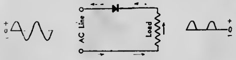


Fig. 4

cycles, current will flow as indicated by arrows, through the lower conductor, up through the load and back to the line through the rectifier and upper conductor. Current can flow during this half cycle because the rectifier has low resistance in this direction. During the negative half cycle, current will attempt to flow in a direction opposite to the positive half cycle, but will be prevented from doing so by the high resistance of the rectifier. Current flow through the load, then, consists of pulses of current, all flowing in the same direction. As indicated by the graph at the right of Fig. 4, these current pulses are actually the positive pulses of the applied AC. Current through the

load is zero during the negative half cycles, so that half of the time the load has no power. Actually, there is some current flow during the negative half cycles but is very small and can be ignored in this discussion. Also due to the fact that the rectifier offers some resistance to the positive current pulses, there will be a voltage drop across the rectifier and the load will not receive the full line voltage.

Half-wave rectification is satisfactory for some uses but is too rough for many applications. Characteristics of a rectified current supply can be greatly improved by employing full-wave rectification. In Fig. 5, a basic circuit for a full-wave rectifier is shown. Notice that four rectifier elements are employed in a bridge connection. To facilitate tracing paths of the current through the circuit these elements are identified by the letters A, B, C and D and junctions between elements are numbered 1 through 4.

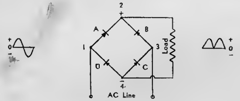


Fig. 5

During a positive half cycle, current will flow from the supply line at R to junction No. 3. B has its high resistance side facing this junction but the low resistance of C offers an easy path and the current will flow through C to junction No. 4. Here current is blocked from reaching junction No. 1 by the high resistance of D, so it takes the path through the lower conductor to the load. Leaving the load, current flows to junction 2. At this point both elements A and B have their low resistance sides facing the junction, but current cannot flow through B because this would lead it back to point R from which it started, so it must go through A to junction 1 and back to the line through point L. During the negative half of the cycle, current will flow from the terminal L to junction No. 1, through D to junction 4, thence through the load and back to junction 2, through B to junction 3 and back to the line at terminal R. The graph at the right of Fig. 5 shows the current output still consists of pulses as it did with the half-wave circuit, but there are now two pulses per cycle and there are no periods of zero voltage. The resulting current gives solenoids and motors more power on a given voltage and relays operate with less chatter or buzz than with half-wave rectification.

To see how such a rectifier is used in a practical application, refer to Fig. 6 which is the circuit diagram for an electrically operated pot pump safety as applied to linotype No. A8 in our composing room. The circuit employs a step-down transformer with 24-volt secondary, the rectifier is a full-wave bridge rated at 2 amperes. A filter condenser, C1, is floated across the rectifier output to smooth out the pulsating DC. The toggle switch SW1 disconnects the solenoid to prevent casting when the operator so wishes. Other features of the circuit will be apparent on examination of the diagram.

Usually, when a DC voltage higher than the AC voltage of the supply lines is needed, a step-up transformer is used to raise the AC to the desired value, then rectified to give DC. It is possible to double the AC line voltage without the use of a transformer by employing two half-wave rectifiers to charge a pair of condensers. The capacitors are connected in series so that the voltage of their individual charges is added together as they discharge into the load, giving an output voltage equal to twice the input.

Fig. 7 is a diagram of a voltage doubler circuit such as is used to power the keyboard triggers on TTS perforators. At A, current flows, as indicated by arrows, from the line at terminal L2 to capacitor C1 and from C1 through rectifier A back to the line at L1. During this half cycle C1 is charged. On the alternate half cycle, current flows from L1 through B to C2 and from C2 back to L2 (Fig. 7-B). On this half cycle C2 receives a charge. Note that C1 and C2 are connected in series. The plus side of C1 is connected to the load, while the minus side is connected to the plus of C2. C2 minus is to the load. Thus C1 and C2, which are charged at line voltage, add their charges to supply the load a DC voltage equal to twice that of the AC line. Current flow through the load is indicated at C in Fig. 7.

The circuit is only satisfactory for use where small current is required. Its output is limited by the total capacity of its condensers and series connection greatly reduces total capacity. Another drawback is that there is no buffer between the DC apparatus and the AC line. Use of a transformer serves to isolate its load from the line, but with the voltage doubler circuit an accidental ground can set the stage for some jolting, if not dangerous, shocks from high voltage DC.

The complete circuit for the TTS keyboard trigger is given in Fig. 8. R1 is a fusible resistor which limits current under normal conditions and acts as a fuse to protect from overloading. R2 is a bleeder across the DC output, serving to stabilize voltage. R3, R4 and R5 are current limiting resistors. Capacitors C3 C4. C5 and C6 are arranged in a tank circuit which is charged through the normally closed contacts on the universal bar. This charge is "dumped" into the tripping magnets when-

ever a key is depressed. The repeat contacts serve to maintain current through the tripping magnets when it is desired to repeat some code a number of times as when running blank tape or rubout.

For additional information on transformers and rectifiers refer to "Basic Electricity", Vol. 3, pp. 49 through 57 and "Basic Electronics", Vol. 1 section on dry metal rectifiers.

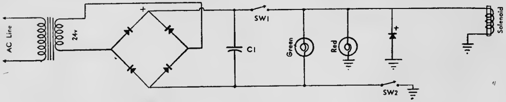


Fig. 6

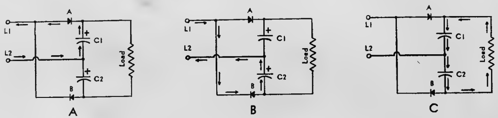


Fig. 7

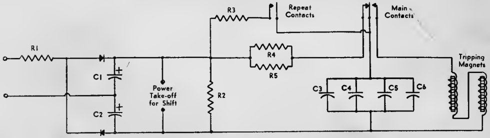
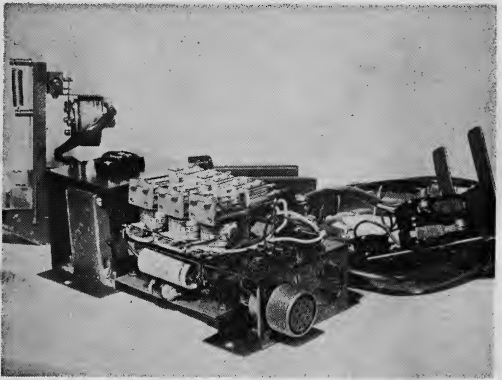


Fig. 8

R1—9 OHM FUSIBLE RESISTOR
R2—50,000 OHM RESISTOR, 10 WATTS
R3—5,000 OHM RESISTOR, 20 WATTS

R4, R5—1,000 OHM RESISTORS, 2 WATTS
C1, C2—60MFD., 350V ELECTROLYTIC CAPACITORS
C3, C4, C5, C6—1MFD., 600V PAPER CAPACITORS

Classified Rule Inserter



COMPLETE CLASSIFIED RULE INSERTER

This device, when attached to a teletypesetter operated linecasting machine, inserts cut-off rules between slugs of type as they are cast.

The electrical components of the rule inserter are: (1) The control box which is mounted on the front, right hand leg of the linecasting machine. This box contains the power supply and the memory relays. (2) Three sets of contacts on the Teletypesetter Operating Unit. They are the No. 1 code lever contact (bail switch) and the No. 2 and No. 3 elevator shaft cam contacts. (3) The three cam switches mounted inside main cam No. 10 on the linecasting machine. (4) The operating solenoid which is attached to the ejecting slide of the rule inserter just to the left of the storage magazine which holds a supply of classified rules. (5) Wiring harness. This is the wires, tubing, plugs, etc. used to connect the other components together.

The TTS perforator operator cuts a specific code in the tape, quad right in our shop, to control the proper placing of the rule in the slugs of cast type. When the tape pins in the selection mechanism of the operating unit on the linecasting machine sense the quad right code the normally open (NO) No. 1 code lever (bail) contacts are closed. The momentary closing of these contacts energizes relay No. 1 (R1) in the memory circuit. At the end of the line containing the quad right code the tape pins sense the elevate code causing the elevator shaft to turn. When this TOU elevator shaft has turned about 20 degrees, the center (No. 2) elevate contacts are closed energizing relay No. 2 (R2) in the memory circuit.

The elevator shaft continues to turn and at 87 degrees the rear (No. 3) elevate contacts are opened de-energizing R1. The elevated line is delivered to the first elevator jaws starting the main cams of the linecaster in motion. A small cam on the inside of main cam No. 10 of the linecaster depresses cam switch

No. 3. This causes no action whatsoever. Next cam switch No. 4 is depressed. Again nothing happens. Cam switch No. 2 is operated next. This action energizes relay No. 3 (R3) in the memory circuit and de-energizes R2. The linecasting machine cycle is completed with no further operations of the rule inserter mechanisms.

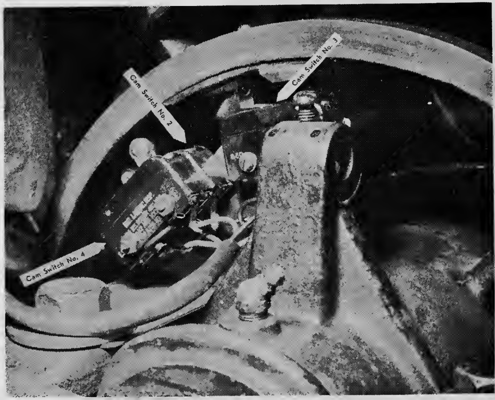
Now a line which has no code for a rule is assembled and elevated. Because of no quad right code the No. 1 code lever contacts are not closed. Therefore R1 is not energized.

As we shall see later R2 cannot be energized unless R1 is energized. So, at the end of the line, as the TOU elevator shaft turns the No. 2 elevate contacts close but do not energize R2. Because R1 has not been operated, opening of elevate contacts No. 3 perform no function.

The main cams of the linecaster again start to turn causing cam switch No. 3 to be operated. This energizes the rotary solenoid mounted on the ejector slide of the rule inserter through a contact of R3 which is still energized from the previous line. When the rotary solenoid operates it pushes a roller on a plunger into the path of a cam attached to the descending first elevator slide. Then the cam on the slide forces the inserter's ejector slide and blade to the right pushing the bottom rule from the magazine. As the main cams continue turning, cam switch No. 4 is operated. This releases R3 which opens the circuit to the solenoid. Cam switch No. 2 is again operated but as there is no signal to transfer from R2 to R3 no action occurs. The linecasting machine completes its cycle leaving all the memory circuit relays in their normal, unoperated condition.

POWER SUPPLY

The electrical components of the rule inserter operate on approximately 24 VDC. The power supply consists primarily of a 115 volt to 28 volt step-down transformer and full wave bridge rectification. There is a 20 MFD, 50V capacitor across the output of the rectifier to dampen the pulsating direct current. A 3 ampere fuse is in the circuit to protect against overload.



CAM SWITCHES MOUNTED ON LINECASTING MACHINE

MEMORY CIRCUIT

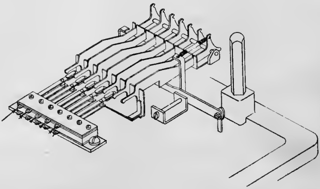
The memory circuit consists essentially of three DPDT relays. However, all three are used only as DPST relays utilizing only the NO contacts. This memory mechanism serves to take a signal for a rule to be dropped from the code lever contacts and hold this signal until the proper time for the rule to be inserted.

The capacitor across the relay coils is to delay de-energizing. The diode near R3 shorts the back EMF from the solenoid to protect contacts on R3 and cam switch 3.

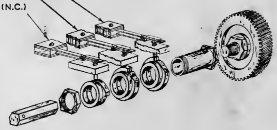
SWITCHES AND CONTACTS

There are a series of contacts and switches to control the relays of the memory circuit and the operating solenoid.

On the TOU the NO No. 1 bail switch or code lever contact and the No. 2 (NO) and No. 3 (NC) elevate contacts are used.



CODE LEVER CONTACTS (BAIL SWITCHES) ON TELETYPESETTER OPERATING UNIT



ELEVATE CAM SWITCHES ON TELETYPESETTER OPERATING UNIT

Mounted over the right hand end of the main cam shaft of the linecasting machine are the three cam switches. These switches are SPDT micro switches. Cam switch No. 2 is wired to use both the NO and NC sides. Cam switch No. 3 uses only the NO contact and cam switch No. 4 is NC.

The code lever contacts send the initial signal to R1 of the memory circuit when a quad right code in the tape is sensed by the tape pins on the TOU. The elevate contacts transfer the signal to R2 and release R1 so that R1 is ready for another signal if the next line contains a quad right code.

Cam switch No. 2 transfers the signal to R3 and releases R2 so that R2 is ready for another incoming signal from R1. Cam switch No. 3 closes the circuit to the solenoid through contacts of R3. Cam switch No. 4 breaks the circuit to R3 releasing it. The solenoid is deenergized when R3 is released.

This sequence of actions allows the memory circuit to store signals for rules to be inserted after two successive linecaster slugs.

THEORY OF OPERATION

(See basic schematic)

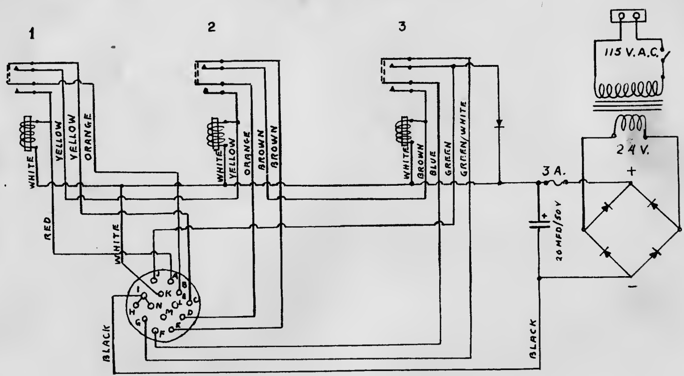
The teletypesetter perforator operator inserts a quad right code in the tape in the line following the last line in an individual classified ad. This code can be placed any place in this line. When the tape is fed into the TOU the quad right code is sensed by the tape pins momentarily closing the NO code lever contact No. 1. This completes a circuit through the coil of R1. With the closing of the NO contacts on R1 this relay is kept energized by a circuit through one set of its own contacts and the NC elevate contacts. Thus, R1 will remain in its operated position after the code lever contacts have re-opened as the quad right code passes beyond the tape pins. At the end of this line the elevate code is sensed causing the TOU elevator shaft to rotate. As this shaft turns the center (NO) elevate contact is closed energizing the coil of R2 through a contact of R1. R2 is kept energized after the NO elevate contact opens by a circuit through one of its own contacts and the NC contact of cam switch No. 2. As the elevator shaft continues to turn, the rear (NC) elevate contacts are opened breaking the circuit to the coil of R1 allowing R1 to return to its normal, unoperated condition.

With elevating and delivery of the assembled line of matrices and spacebands, the main cams of the linecasting machine start to turn. Cam switch No. 3 is depressed almost immediately. This completes no circuit, so there is no action. Next, cam switch No. 4 is depressed but again nothing happens. Now cam switch No. 2 is depressed. This energizes the coil of R3 through the NO contact of cam switch 2 and a contact of R2. The circuit to coil of R2 is opened by breaking of the NC contact of cam switch No. 2. R3 is held closed through its own contacts and the NC contacts of cam switch 4 after cam switch 2 has returned to its normal position. (Keep in mind the fact that the code lever contacts, the elevate contacts and the cam switches are operated only momentarily and then return to their original position.) The linecasting machine completes its cycle leaving R3 as the only relay still energized.

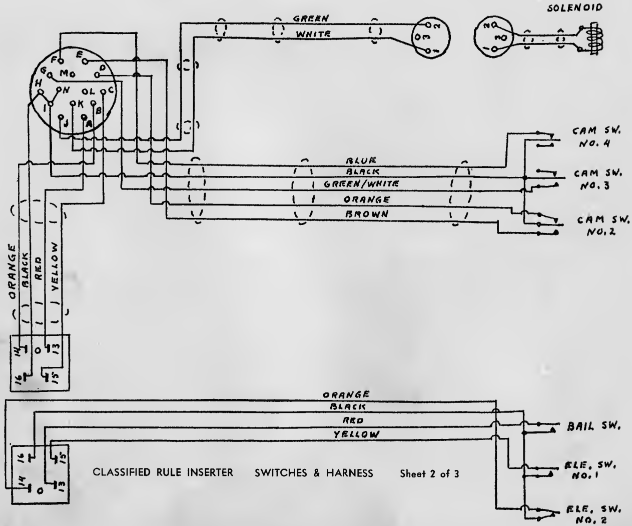
The next line has no quad right code so the code lever contacts do not close and R1 is not energized. When this line is elevated the closing of the NO elevate contacts cannot energize R2 because R1 is not closed. The normally closed elevate contact has no function now as R1 is already open.

With delivery of this line the main cams of the linecasting machine start turning. Again cam switch No. 3 is depressed almost immediately. The rotary solenoid is energized through the NO contact of cam switch No. 3 and a contact of R3. Next cam switch No. 4 is pressed down. R3 is released when the NC contact of cam switch No. 4 opens. The solenoid is de-energized when either R3 and/or cam switch No. 3 is released. R3 must be energized and cam switch 3 must be depressed to complete the circuit to the solenoid. The solenoid is operated only long enough for the first elevator slide cam to start the rule ejecting slide and blade moving. Now cam switch No. 2 is depressed. However, there is no signal to transfer from R2 to R3 so this time cam switch 2 performs no function.

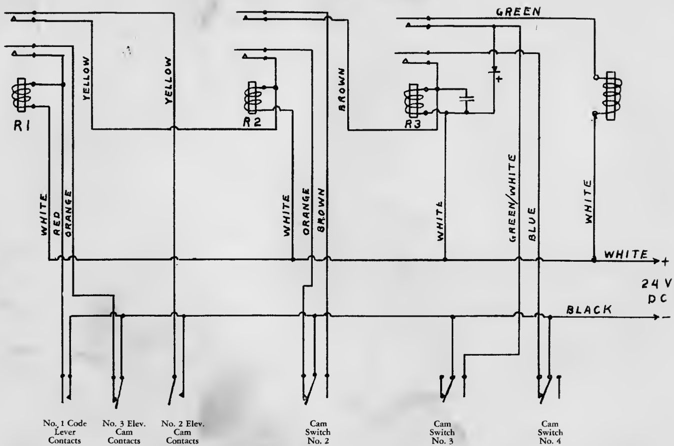
This operational description is based on the premise that there will not be quad right codes in successive lines of tape. However, the rule inserter will operate just as well from tape that has rule codes in successive lines. It can easily be seen how this is possible by looking at the basic schematic.



CLASSIFIED RULE INSERTER　　CONTROL PANEL　　Sheet 1 of 3



CLASSIFIED RULE INSERTER SWITCHES & HARNESS Sheet 2 of 3



CLASSIFIED RULE INSERTER BASIC CIRCUIT

Electric Quadder Controls

This instalment of "electricity for machinists" class is almost entirely reprinted from manufacturers' manuals for the equipment covered. Since the subject of this series is electrical equipment, reference to mechanical functions is largely omitted.

General Sequence of Operation Linotype Hydraquadder

The Electrically Controlled Hydraquadder can be operated by quadding signals from a Teletypesetter tape so that the quadding system is entirely automatic and controlled by the Teletypesetter operating unit, or it may be operated by push-button control so that the Linotype operator may select a quadding or centering function by pressing the proper push-button on the selector push-button box located at the right of the keyboard.

The sequence of operation of the Electrically Controlled Hydraquadder is the same for push-button operation as it is for Teletypesetter operation, except that the first stage relays are not used and the second contacts of the assembling elevator transfer switch perform no function when the Hydraquadder operation is controlled by push-button. When a push-button is depressed and the assembling elevator raised, the first contacts of the transfer switch close, and the signal for quadding or centering is transferred directly to the second stage relay or relays.

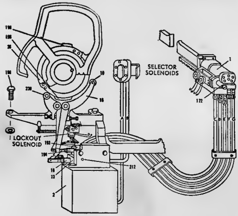


Fig. 1 Side View of Complete Hydraquadder

The sequence of operation thereafter is the same for both push-button and tape operation.

The general sequence of operation of the Electrically Controlled Hydraquadder is as follows:

1. The signal (either tape or push-button) is put into the electrical control circuit.

2. As the first elevator starts its descent, the secondary control valve is closed, before the main control valve reaches the jaw closing position. Simultaneously the selector solenoid (or solenoids) are energized by the closing of the actuating switch in accordance with the quadding signal, to move the appropriate selector latch to position the selector slide. Also the lock-out solenoid is energized to move the lock-out latch clear of the main control valve operating lever.

3. As the secondary control valve closes, the hydraulic system between the main control valve and the cylinder housing is closed off so that no jaw motion occurs. The hydraulic fluid is diverted to the selector cylinder and pressure is applied against the selector piston to move the selector slide against the selector latch to position the selector valve for the predetermined quadding function.

4. After the first elevator is seated on the vise cap, the secondary valve is opened and fluid then flows to the selector valve in the cylinder housing, where it is directed to the appropriate cylinder for the quadding or centering function called for.

Also after the first elevator is seated on the vise cap, the clearing switch at the back of the machine is opened, releasing the selector solenoid (or solenoids) and clearing the second stage relay (or relays) to make them available for the next line.

When the piston motion is stopped by the vise jaws contacting the line of matrices, the fluid pressure rises and the high pressure relief valve opens, permitting fluid to escape to the sump, thus maintaining the proper vise jaw force against the line of matrices.

Simultaneously with the closing of the L.H. vise jaw against the line of matrices, the detent in this jaw is actuated to close the jaw switch and the pot pump solenoid is energized to move the stop lever clear of the pot pump lever catch block which will permit the cast to be made.

5. Before the first elevator rises for matrix toe alignment, the main control valve shifts to permit the fluid to flow to the low pressure relief valve, reducing the vise jaw force sufficiently to permit vertical alignment of the matrices.

6. The main control valve again returns to the jaw closing position and high pressure is maintained during casting.

7. After the cast is completed, the main control valve is moved to the "wipe" position and the Hydraquadder fluid again flows through the low pressure relief valve, so that a low vise jaw force is exerted against the line of matrices during the initial upward movement

of the first elevator. The low force provides a wiping action of the matrices against the jaw faces to prevent metal buildup.

8. When the first elevator has risen a short distance above the vise cap, the main control valve is shifted to the return position simultaneously with the closing of the secondary control valve. The fluid exerts pressure on the right-hand side of the piston in the selector cylinder and the piston is moved to the left to return the selector slide and associated parts, such as the selector valve, justification block-out lever, etc., to normal position.

9. The secondary control valve opens and hydraulic fluid then flows to the vise jaw cylinders, moving the jaws back to their normal position.

10. The main control valve spindle is then moved to normal position and the hydraulic fluid circulates from the sump, through the pump and back through the main control valve to the sump.

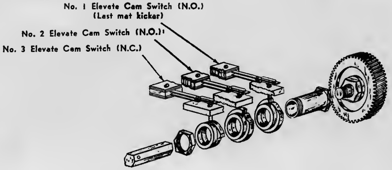


Fig. 2 Teletypesetter Operating Unit Cam Switch Assembly

Description of Sequence of Electrical Operation —TTS Tape Control

Fig. 2 and 3

For tape operation, the clearing solenoid in the push-button box is energized when the TTS operating unit cam shaft starts to turn, by the closing of the leaf switch located in the Teletypesetter Operating Unit. The movement of the solenoid actuates a button release bar and any QL, QR or CEN push-button which is depressed is returned to its "up" position. The solenoid is not energized every cycle, but only when one of these push-buttons is depressed.

Quad Left (Tape Code 0134)

1. Tape code 0134 closes QL bail switch in TTS operating unit momentarily, energizing first stage relay K-2. Holding contacts on the relay hold the relay K-2 in the closed position, retaining the QL signal in the first stage of the memory circuit.

2. During the rise of the assembling elevator, the transfer switch contacts are actuated in sequence.

3. First the transfer switch plunger closes

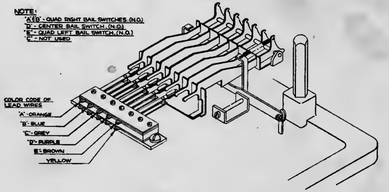


Fig. 3 Underside of TTS Operating Unit Showing Bail Switches

the normally open switch contacts and the QL signal is transferred from the first stage relay K-2 to the second stage relay K-4. Holding contacts in relay K-4 hold the relay in closed position, retaining the quadding signal in the second stage of the memory circuit.

4. Further movement of the transfer switch plunger opens the second or normally closed switch contacts and releases the first stage relay K-2, thus clearing the relay for a new quadding signal.

5. As the Linotype cams start to rotate, the actuating switch is closed to complete the circuit between the second stage relay K-4 and the selector latch solenoid, energizing this solenoid.

6. The closing of the actuating switch also energizes the lockout solenoid to move the latch clear of the main control valve operating lever to permit it to function.

7. After the first elevator is seated on the vise cap, the clearing switch is opened. This de-energizes the second stage relay K-4, the selector latch solenoid, and the lockout solenoid.

Quad Right (Tape Code 01234)

The electrical sequence for obtaining Quad Right is basically the same as for Quad Left, except that both relays K-1 and K-2 in the first stage and both relays K-3 and K-4 in the second stage are energized, which results in both selector latch solenoids being energized. The circuit is conditioned for the Quad Right function by the closing of bail switches A and B, in the TTS Operating Unit as a result of tape code 01234.

Center (Tape Code 02345)

The electrical sequence for obtaining Center is basically the same as for QL and QR except that only relay K-1 in the first stage and relay K-3 in the second stage are energized, which results in selector latch solenoid being energized. The circuit is conditioned for the Center function by the closing of bail switch D, in the TTS Operating Unit, as a result of tape code 02345.

Description of Sequence of Electrical Operation—Push-Button Operation

Quad Left

1. "Q.L." push-button closes switch in push-button box so current will be directed to the second stage relay K-4 when assembling elevator is raised.

2. Raising the assembling elevator then actuates the first set of contacts of the transfer switch which results in energizing relay K-4.

3. As the Linotype cams start to rotate, the actuating switch is closed.

4. This completes the circuit through relay K-4 to selector latch solenoid energizing the solenoid.

5. With the closing of actuating switch, the lockout solenoid is energized to move the lockout latch clear of the main control valve operating lever.

6. After the first elevator is seated on the vise cap, the clearing switch is opened, releasing the second stage relay K-4 for the next signal.

Quad Right

The electrical sequence for obtaining Q.R. for push-button operation is basically the same as Q.L., except that both relays K-3 and K-4 in the second stage are energized which results in both selector latch solenoids being energized.

Center

The electrical sequence for obtaining Center for push-button operation is basically the same as for Q.L., except that relay K-3 in the second stage is energized which results in selector latch solenoid being energized.

The Power Supply Box
Figure 4

Since the electrical system for controlling the Hydraquadder operates on low voltage Direct Current, it is the function of the Power Supply Unit to transform the incoming 110 or 220 volt A.C. power supply to approximately 24 volts A.C. and then convert to D.C.

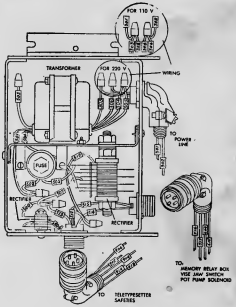


Fig. 4 Hydraquadder Power Supply Box

The transformer in the power supply box reduces the incoming line voltage to 24 volts Alternating Current and the large disk type rectifier changes the alternating current to direct current.

A 2 ampere fusestat is located in the power supply box to protect the electrical circuit against overloads.

The small, square, four-plate rectifier in the power supply box is in the circuit to dampen any arcing which might occur across the L.H. vise jaw switch contact points when the switch opens.

There is a four-terminal socket located on the power supply box to which the harness plug from the various electrical components of the Hydraquadder and electrical L.H. Vise Jaw Safety are connected. A five-terminal socket located on the power supply box provides the connection for the harness plug from the TTS keyboard safeties.

The primary leads of the transformer can be connected so that the same power supply box is used for either a 110 volt or 220 volt A.C. power source.

The Memory Relay Box
Figure 5

The function of the relays in the memory relay box is to retain or transmit the quadding or centering function, at the proper time in the machine cycle. Each of the 4 relays used is identical in its internal wiring and may be interchanged with the others.

When the Hydraquadder is operated by push-button control only, the two first stage relays K-1 and K-2 are not used in the circuit, the signal from the push-button selector box going

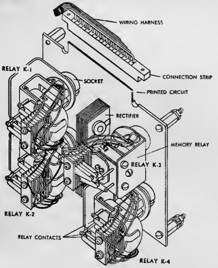


Fig. 5 Hydraquadder Memory Relay Box

directly to the second stage relays K-3 and-or K-4 upon actuation of the transfer switch.

When the Hydraquadder is operated by tape control, the first stage relays K-1 and-or K-2 and the second stage relays K-3 and-or K-4 are used, the signal being transferred from the first stage to the second stage relays as the transfer switch is actuated. This provides the memory feature, since two signals can be "memorized" by the first and second stage relays while a third line is being cast.

The first stage relays K-1 and K-2 are located at the left in the memory relay box. Relay K-1 is the upper one and K-2 is lower one.

The second stage relays are located at the right in the memory relay box. Relay K-3 is the lower one and K-4 the upper one.

Relay K-1 operates for a CEN signal (for tape control only.

Relay K-2 operates for a QL signal (for tape control only).

Relays K-1 and K-2 operate simultaneously for a QR signal (for tape control only).

Relay K-3 operated for a CEN signal (for either push-button or tape control).

Relay K-4 operates for a QL signal (for either push-button or tape control).

Relays K-3 and K-4 operate simultaneously for a QR signal (for either push-button or tape control).

The Push-Button Box
Figure 6

The Push-Button Box is used to control the Hydraquadder functions by means of the operator depressing the proper push-button for the Quadding or Centering function desired. Construction of the switches in the box is such that a depressed push-button stays in the down position and is released only by depressing another push-button. Depressing the push-button results in the closing of switch contacts to prepare the electrical circuit for the function selected.

The Push-Button Box also incorporates a solenoid to actuate a button release bar to automatically return any depressed push-button to "up" position whenever TTS tape is used.

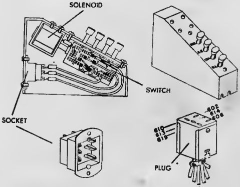


Fig. 6 Hydraquadder Push-Button Box

Omitting Quadding Signal in Tape—In the case of the "Reg." push-button, the switch contact which completes the circuit to the push-button clearing solenoid is opened so that the clearing solenoid is not energized when a Teletypesetter tape is used.

With this arrangement, if the same quadded function is desired for a number of consecutive lines during tape operation and it is desired to omit the quad signal in the tape, the appropriate "quad" or "center" button and the "Reg." button are depressed simultaneously. Since the clearing solenoid will not be energized when the "Reg." button is down, the quadding signal will originate from the push-button box during tape operation; no tape signal is required.

Action of Push-Button Clearing Solenoid
Fig. 6

As previously mentioned, there is a clearing solenoid incorporated into the design of the Push-Button Box which prevents the possibility of a depressed push-button causing a signal to enter the memory circuit when quadding or centering signals from tape are being used.

A Push-Button Release switch in the TTS Operating Unit is closed momentarily when the elevate signal in the tape causes the operating unit to raise the assembling elevator. The closing of this switch results in the solenoid in the Push-Button Box being energized. The movement of the solenoid actuates a button release bar and if a "Q.L.," "Q.R.," or "CEN." push-button is depressed, the button is returned to its "up" position automatically.

Switch S-801 is actuated by means of a fiber pin riding on a small cam on the Teletypesetter Unit elevator cam shaft, as the cam shaft starts turning to raise the assembling elevator in response to the "elevate" signal in the tape. As the cam starts to turn, the fiber pin drops into a recess in the cam contour which allows the switch contacts to close momentarily.

The solenoid is not energized for every cycle, but only when a quadding or centering button is depressed and tape is fed into the TTS Operating Unit. Also, if the "Reg." button is depressed, the switch contact which completes the circuit to the push-button clearing solenoid is opened so that the clearing feature is inoperative and it is possible to obtain a quadding or centering function for tape operation, as described under the heading "Omitting Quadding Signal in Tape."

Actuating and Clearing Switches

The actuating switch has the function of completing the circuit between the second stage memory relays (K-3 and-or K-4) and the selector solenoids, and the lock-out solenoid, in accordance with the quad or center function selected. This is a normally open switch actuated by a cam shoe on the transfer and delivery cam.

After the first elevator is seated on the vise cap, the clearing switch (normally closed) is opened by the projection on the cam shoe. This de-energizes the selector latch solenoids, the lock-out solenoid, and the second stage relays, so that they will be ready to receive the next signal.

Transfer Switch
Figure 7

The transfer switch is located at the right of the keyboard on push-button operated machines and at the lower left of the TTS operating unit when the machine is operated by tape. The transfer switch plunger is operated by the assembling elevator lever handle as the assembling elevator is raised. On TTS machines, the transfer switch plunger is operated by the spring stud in the TTS assembling elevator lever. It is the function of the transfer switch (TTS operation) to transfer the quadding or centering signal from the first stage relay or relays (K-1 and-or K-2) to the second stage relay or relays (K-3 and-or K-4) and then to release the first stage relay or relays (K-1 and-or K-2) so they are ready to receive the next signal.

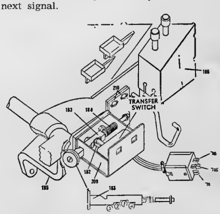


Fig. 7 Hydraquadder Transfer Switch Assembly

The switch used to perform these functions is a single Micro-Switch having a double set of contacts which are actuated in sequence. The first set of contacts are normally open and are closed by the movement of the plunger as the assembling elevator rises. For tape operation closing of these contacts transfers the signal from the first relay stage to the second relay stage. The second set of contacts are normally closed and as the assembling elevator continues to rise, the plunger is moved further to actuate the switch and cause these contacts to open, releasing the relays in the first stage.

For push-button operation, closing of the first set of contacts completes the circuit between the push-button box and the second stage relays. The first stage relays are not used for push-button operation. The second set of contacts perform no function in push-button operation since the first stage relays are not used.

The Transfer Switch Plunger is returned to its normal position, as the assembling elevator returns to normal position, by means of a coil spring on the plunger.

The plunger is provided with steps to actuate the switch roller, causing the switch contacts to close and open in sequence. Step 1 is the normal position for the switch. When the switch roller is on step 1 the first set of contacts are open and the second set are closed. As the plunger is moved in, the roller rides up on step 2 and the first set of contacts are closed. Further movement of the plunger inward results in the roller riding up on step 3. The first set of contacts remain closed and the second set of contacts are opened. When the assembling elevator returns to normal position, the plunger is returned to normal or No. 1 position by spring action.

When the plunger is pulled forward by the operator for recasting, as described under the heading "Recasting (Push-Button Operation)" the switch roller is on step 4, which closes the first set of contacts in the switch to complete the circuit for recasting, thus holding the first set of contacts in closed position.

Selector Latch Solenoids
Fig. 1

The selector latch solenoids 203 and 204, which have been mentioned previously under the heading "The Selector Cylinder and Latch Assembly," have the function of moving the selector latches into position for controlling the movement of the selector slide. These solenoids are energized either singly or together, at the proper time in the machine cycle to cause the desired quadding or centering function.

The action of the solenoids is controlled by the lower contacts on the second stage relays K-3 and K-4 and by the actuating switch.

For centering, when relay K-3 is energized, the circuit to the latch solenoid 203, is completed as the actuating switch contacts are closed. This results in the Hydraquadder moving the vise jaws through the centering function.

When relay K-4 is energized, the circuit to the latch solenoid 204 is completed as the actuating switch contacts are closed. This results in the Hydraquadder moving the R.H. vise jaw through the Quad Left function.

When both relays K-3 and K-4 are energized and the actuating switch contacts are closed, the circuit is completed to both latch solenoids. This results in the Hydraquadder moving the L.H. vise jaw through the Quad Right function.

When the projection on cam shoe contacts clearing switch, the switch opens which de-energizes the selector latch solenoid (or solenoids).

Lockout Solenoid
Fig. 1

The main control valve operating lever lockout solenoid has the function of moving the lockout latch clear of the main control valve operating lever when a quadding or centering signal is sent through the circuit. For regular operation the lockout latch remains in normal position preventing movement of the main control valve spindle 16.

The lockout latch solenoid is wired in the circuit with the second stage relays K-3 and K-4 so that the solenoid is energized when either the K-3 or K-4, or both, relays are energized and the actuating switch is closed by cam shoe. Energizing of the lockout solenoid occurs simultaneously with the energizing of the selector latch solenoid (or solenoids).

The lockout solenoid is of the rotary type. A spring returns the lockout latch to normal position when the solenoid is de-energized.

The purpose of preventing movement of the main control valve spindle during regular operation, is to prevent the flow of hydraulic fluid to the selector cylinder, at the start of the cycle, since this would move the selector valve to the Quad Left position. Instead of obtaining regular operation the machine would then be quadding left.

TTS Operating Unit Bail Switches
Figure 3

Located in the Teletypesetter Operating Unit are 5 leaf-type switches which are actuated by the keyboard bails. Four of the five switches are used. Switch C is a spare and has no connection out of terminal 3 of the 8-prong plug on the Teletypestter unit. The purpose of the bail switches is to transmit the tape code signal to the appropriate first stage relay (or relays) in the memory circuit to obtain the quadding function desired.

Quad Left tape code (0134) results in bail switch E closing, completing the circuit to the first stage relay K-2. Center tape code (02345) closes bail switch D which in turn energizes first stage relay K-1. Quad Right tape code (01234) closes bail switches A and B to complete the circuit to both first stage relays K-1 and K-2.

L.H. Vise Jaw Safety Switch
and Pot Pump Solenoid

The Left-Hand Vise Jaw Electric Pot Pump Safety operates during both quadding and non-quadding cycles of the Linotype. The purpose of this safety is to prevent a cast from occur-

ring if the matrices are not properly held, between the vise jaws.

When the line of matrices is held between the vise jaws, a switch plunger tip protruding from the left-hand vise jaw is forced flush with the face of the jaw. This closes the circuit to the solenoid, located above the pot pump lever catch block. When the switch plunger is depressed the circuit is closed and the solenoid is energized to pull the catch lever out from under the pot pump lever to permit the plunger to descend for the cast.

In order to permit the operator to hold the pump stop closed if he does not want a line which normally would cast, a spring is connected between the solenoid and the catch lever. The operator then presses the pot pump stop lever operating lever, and when the solenoid is energized it merely expands the spring instead of moving the catch lever clear of the pot pump lever.

The L.H. Vise Jaw Safety circuit receives its power from the power supply box via the four-terminal plug on the box. The circuit is a "grounded circuit" in that the Linotype machine frame is used to complete the circuit between the pot pump solenoid and the power supply box. Since there is only about 18 volts direct current being used it is completely safe.

There are two wires (516 and 517) leading from the power supply box four-terminal plug, to the L.H. Vise Jaw Safety. Wire 517 connects to the insulated contact 171 on the left-hand vise jaw switch through wire 511. When the switch is closed by the plunger in the jaw being depressed, the circuit is grounded to the machine frame. Wire 516 is connected to the pot pump solenoid coil through wire 508. Wire 509 connects coil to ground on the machine frame. When the L.H. vise jaw switch is closed, the circuit is completed through the machine frame and the solenoid is energized to pull the catch lever clear of the pot pump lever, permitting the slug to be cast.

The vise jaw switch is a complete assembly in itself. It assembles into the vise jaw and is held in position by means of a retaining ring which snaps into a groove in the inner wall of the vise jaw.

An insulated terminal on the end of the switch is part of an insulated contact assembly. The insulated contact is held stationary with respect to the main switch assembly by a bakelite pin. The other contact is grounded to the machine by a sliding connection between the switch plunger assembly and the vise jaw. A small spring permits movement of the contact so that over-travel is allowed, to avoid damage to both contacts when they meet. The plunger contact is normally held away from the stationary contact by a spring so that there is a .010 inch gap between contacts when no pressure is exerted on the plunger.

General Maintenance Information on the Electrical Control Circuit

Testing Equipment

A circuit analyzer or multimeter, which is capable of measuring voltage, current and resistance for AC and DC circuits, is the most useful instrument for trouble-shooting the Hydraquadder electrical equipment.

General Check Points for Servicing

In the event of difficulty with operation of the Hydraquadder, time can be saved in correcting the trouble by using a methodical system to check the functions of the mechanism in logical sequence.

The first thing to do, is to determine whether the difficulty is of an electrical, mechanical or hydraulic nature or a combination of these.

Since the electrical circuit involved is more simple when operating by push-button than by tape, the quadder should be put through its functions using the push-buttons and the action of the relays and solenoids observed to see if they are being energized and de-energized in accordance with the sequence of operation given in the chapter entitled "Operation." If the sequence is correct then the tape-controlled function should be observed in like manner, to see if that portion of the circuit which is involved when operating by tape may contain the source of difficulty. If all electrical functions are occurring in proper sequence for both tape and push-button operation, it can be assumed that the electrical circuit is all right and trouble is of a mechanical or hydraulic nature.

Checks for Difficulty in Operation

When difficulty with the operation of the Hydraquadder is encountered it is possible that one of the following symptoms will be evident, in which case there are definite checks which can be made in an effort to eliminate the difficulty. When operating by push-button, the first stage relays, the TTS operating unit bail switches and wiring between these units are not used. Where difficulty with tape operation is encountered, the quadder should be first tested by using the push-buttons. If it then operates correctly, it can be assumed that the difficulty is in either the first stage relays, the bail switches or the wiring.

Symptom: No quadder function occurs for QR, QL or Center signal.

Check for Push-Button Control

1. Depress QR push-button and check action of the second stage relays K-3 and K-4. Both relays should close as the transfer switch plunger is pushed in.
2. If relays do not close, check the following:
   (a) Transfer switch action.
   (b) Examine fuse in power supply box.
   (c) Voltage output of power supply box. Minimum voltage of 18 volts DC should be read across wires 507 and 510 in the

power box, Fig. 4. If voltage is less than 18 volts DC, disconnect wire 501 from wire 502 in the power box and connect the 28 volt tap wire 505 on transformer to wire 502 in place of wire 501. Recap wire 501.

(d) Wiring between transfer switch and relay box and selector switch box should be checked for continuity.

(e) Relays should be examined for possibility that contact actuating pins are binding. Substitute relays K-1 or K-2 or both to determine if relays K-3 and K-4 are functioning properly.

(f) Clearing switch should be checked to be sure the switch contacts are closed, until contacted by the cam shoe.

3. If both relays K-3 and K-4 close as transfer switch is actuated by raising the assembling elevator, check the following:

(a) Observe the action of the two selector solenoids 203 and 204, Fig 1, as the actuating switch is closed. The two selector latch solenoids and the lockout solenoid should be energized as the switch is closed.

(b) If solenoids are not energized, check the actuating switch and the wires 616 and 622 for continuity.

4. Cycle machine through the Q.R. function and observe action of the operating levers and the main and secondary control valve spindles. Make certain the lockout latch clears the operating lever and the lever rollers follow the contour of the cams. Be sure the springs are on the operating levers.

Check for Tape Control

1. If Hydraquadder operates satisfactorily when controlled by push-button, but does not function properly when using tape, proceed as follows:

(a) Remove TTS operating unit driving belt. Then put a tape with a QR code combination into the operating unit and turn the operating unit pulley by hand, observing the action of first stage relays K-1 and K-2. Relays K-1 and K-2 should close as the code signal for QR is read by the TTS operating unit tape pins.

(b) If relays K-1 and K-2 do not close in response to the tape code signal, check the bail switches in the TTS operating unit to be sure they are functioning properly. Temporarily substitute relays K-3 and K-4 to determine if the relays are at fault. Check wiring between operating unit and memory relay box.

(c) Check action of clearing switch. This is a normally closed switch and is opened by contact with the cam shoe.

(d) Check the transfer switch action. As the plunger is pushed forward, there should be two audible clicks. At the first click, the first set of contacts is closed to complete the circuit which energizes the second stage relays. At the second click, the second set of contacts is opened which deenergizes the first stage relays.

Symptom: QL. function occurs when signal for QR is given, or Center function occurs when signal calls for QR.

Check for Push-Button Control:

1. With the QR push-button depressed, push in transfer switch plunger and observe action of second stage relays K-3 and K-4. Both relays should close as the transfer switch is actuated. If only relay K-4 closes, a QL function will occur. If only relay K-3 closes, a Center function will occur.
   If this is the case, check the following:

(a) Relays—Temporarily interchange first stage relays with second stage relays to determine if K-3 or K-4 relays are at fault.

(b) Relay socket terminal connection to underside of printed circuit may be open.

(c) Insufficient voltage in circuit to operate both relays simultaneously. If voltage is less than 18 volts D.C., use wire 505 in place of wire 501 to increase voltage as previously explained.

2. If both relays K-3 and K-4 close as the transfer switch plunger is pushed in and with the QR push-button depressed, check the following:

(a) Close the actuating switch manually and observe action of the selector latch solenoids. Both solenoids should energize as the switch is actuated. Also check to see that the latch pivots freely and that the latch spring pressure is not too strong.

(b) Check wires to the solenoids for continuity.

Check for Tape Control:

If the Hydraquadder operates satisfactorily when controlled by push button, but does not function properly when using tape, proceed as follows:

(a) Remove TTS operating unit driving belt. Then put a tape with QR code combination into the operating unit and turn the operating unit pulley by hand, observing the action of the first stage relays K-1 and K-2. Relays K-1 and K-2 should close as the code signal for QR is read by the TTS operating unit tape pins.

(b) If relays K-1 and K-2 do not close in response to the tape code signal, check the bail switches in the TTS operating unit to be sure they are functioning properly. Temporarily substitute relays

K-3 and K-4 to determine if the relays are at fault.

(c) Check wiring between TTS operating unit and memory relay box.

(d) Check push-buttons to be certain they are in "up" position.

Symptom:

1. QL, QR or Center function recurs after push-button selection is made for regular, or when no quadding or centering code is in the tape.
2. QR function repeats even though push-button selection or tape code is changed.
2. QR function repeats even though push-button selection or tape code is changed.
3. QR function occurs when QL push-button selection or QL tape code is used following Center selection.
4. QR function occurs when Center pushbutton selection or Center tape code is used following QL selection.

Check for Both Push-Button and Tape Operation

1. Check the clearing switch to be certain it is being properly actuated by the shoe on the cam. This switch clears the second stage relay(s) for the next signal. If this switch is not functioning properly to de-energize the second stage relay(s) any of the above symptoms will occur.
2. Check the action of the transfer switch. See that spring on plunger is returning plunger to normal position after assembling elevator descends, and that the two sets of contacts of the transfer switch are functioning properly in sequence. Make sure the relationship of the switch roller to the plunger is correct.

Additional Check for Tape Control:

1. Check TTS operating unit bail switches. If one or more fail to open after being actuated momentarily for a quad or center function, then any of the above symptoms will occur.
2. Check to determine if a Quad or Center button remains depressed during tape operation when the assembling elevator starts to rise after an "elevate" signal in the tape. Any depressed Quad or Center button in the push-button box should automatically return to the "up" position by the No. 2 elevate cam switch in the TTS unit, Fig. 2, and the push-button clearing solenoid in the push-button box.

   If this clearing action does not occur and a Quad or Center push-button remains depressed after an elevate signal is received during tape operation, then the push-button signal will enter the memory circuit.

   The action of switch No. 2 elevate cam switch and the push-button clearing action are explained under "Action of the push-button clearing solenoid" under III Operation.
3. The first stage relays should de-energize when the second set of contacts of the transfer switch open (second click). Check the transfer switch for proper action of the first and second set of contacts.

Symptom: Quad or Center signal is lost on waiting line.

Check: Clearing switch. This switch may be opening momentarily at the improper time in the cycle due to vibration or interference.

On mixer Linotypes, where the switches are attached to the second elevator safety pawl switch may open momentarily, if there is excessive vibration of this pawl during operation, the signal for the waiting line will be lost.

Weakening the second elevator safety pawl spring will reduce the vibration of the pawl. It is also suggested that the spring of the switch be strengthened.

Make sure that the switch is not actuated by interference with the cam.

Symptom: Selector handle turns to proper position for the quadding function selected by the tape or push-button and selection is made, but the vise jaw(s) do not close for quadding or centering.

Check: Examine secondary control valve lever and spindle for a possible bind which is preventing the valve from returning to normal position after selection is made. Also see that the return spring is on the lever and exerting sufficient tension to bring the lever and secondary control valve spindle back to normal position after the selection occurs. If the secondary control valve spindle remains in the closed or forward position after the selection has occurred, the hydraulic fluid is prevented from flowing to the vise jaw piston cylinders to move the vise jaws.

Symptom: Electric Left-Hand Vise Jaw Safety does not operate.

Check: 1. Check vise jaw switch action by disconnecting the wire 511 at the knife connector and connecting it to one test lead of an ohmmeter. The other ohmmeter test lead should be grounded to a clean part of the Linotype machine. When vise jaw switch detent is depressed, the resistance should be zero ohms and when the detent is in normal position the resistance should be infinity. If switch is sticking, disassemble and inspect for bind.

2. Check the pot pump solenoid for possibility of a bind which is preventing the rotary movement of the solenoid. Check the spring which connects the solenoid to the pot pump stop lever for the possibility that the spring has not sufficient tension to move the stop lever when the solenoid is energized.

3. To check the solenoid electrically, disconnect the wire 508 at the knife connector and wire 509 from ground and measure the resistance with an ohmmeter from either lead to the machine frame. If the solenoid is not grounded within the casing the resistance should be infinite. The resistance of the solenoid between wires 508 and 509 when disconnected from the knife connectors should be between 17 and 21 ohms.
4. Check the wiring from the power box to the vise jaw switch and solenoid for continuity.
5. If the pot pump solenoid is energized at the wrong time in the cycle and for no apparent reason, it is possible that a ground condition in some other electrical component on the machine is permitting current to flow to the solenoid. In this case all wiring on the machine should be carefully examined for a grounded wire, especially under the harness clamps which hold the harness to the machine.

Principles of the Selectro-Matic Quadder

The Selectro-Matic Quadder consists of three principle divisions. They are:

1. The Memory System, which remembers signals and delivers them to the Quadder mechanism as each line reaches casting position.

2. The Hydraulic Unit, which provides the actuation necessary for moving the Quadder mechanism.

3. The Quadder Mechanism, which accepts signals from the Memory system, and, under Hydraulic Actuation, controls the Vise Jaw or Jaws for the required quadding function.

The Memory System

The Memory System requires no specialized electrical knowledge, either for operation or maintenance. The Memory System is diagrammed here, showing the route of quadder signals.

When the Selector Button is depressed, a circuit is completed through the Short Line Switch to the Transfer Box. The Short Line Switch, when closed by the Trip, will cancel any quadding signal, since the line is then full enough to justify.

Assuming that the line is short of full measure, quadding is then required. When one of the Selector Buttons is depressed the signal is held in the Selector Assembly until the Assembling Elevator rises. As the Elevator rises the plunger in the Memory Transfer Box is depressed, transferring the quadding signal to the relay or relays in the Memory Control Box. These relays remain energized, holding the signal until a pin on the Hydraulic and Switch Acutating Cam closes the Solenoid Actuating Switch through a lever. This transfers the signal from the relays to Solenoids A-A, in the lower part of the quadder housing. Energizing Solenoids A-A causes Pawls to engage either or both Vertical Racks, which then provide for left, right or center quadding. (Fig. 15)

As the Solenoids A-A are energized they also close either or both Micro Switches. This completes a circuit to the Justification Stop Pawl Solenoid, locking out the Justification Rod to prevent Spaceband drive for quadding.

During casting, the relays in the Memory Control Box are cleared for the following quadding signal by the Relay Clearing Switch. After casting the Solenoid Actuating Switch is closed for the second time energizing Solenoids B-B to disengage the pawls from the vertical racks. This returns the quadder mechanism to normal, ready for the next signal.

The Hydraulic Actuating Unit

The basic function of the Hydraulic Actuating Unit is to raise the Actuating Slide attached to the vertical racks in the Quadder Mechanism to provide left, right or center quadding. This is achieved by depressing a piston in the master cylinder, by the specially designed, outboard Hydraulic and Switch Actuating Cam. Hydraulic power is transmitted through a connecting hose to a piston in the slave cylinder, raising the piston and the vertical racks. This provides the necessary actuation for quadding. The Cam, in addition to actuating the hydraulic system, allows the jaws to back off slightly between first and second justification to permit proper alignment of matrices to mold. A relief in the cam is also provided after casting, so the matrices are guided with a light wiping motion but not held tightly, as they rise out of the vise jaws. (Fig. 8)

A reservoir and two valves are parts of the hydraulic system. A relief valve opens when sufficient vise jaw pressure for proper casting has been attained, returning the excess fluid to the reservoir. After casting, fluid is syphoned from the reservoir through a check valve back into the master cylinder. This refills the cylinder for the next quadding cycle.

The Quadder Mechanism

As the Hydraulic Piston, in the Slave Cylinder rises, it carries with it the Actuating Slide, which extends through the back of the quadder housing. Inside the quadder housing, the Slide Block is attached to the Actuating Slide, and it rises with each machine cycle. When quadding is required, the energizing of the "A" Solenoids causes Operating Pawls to engage with the Vertical Racks. As the Slide Block rises it carries the Vertical Racks with it. The Vertical Racks are engaged with gears, which, in turn, move the Horizontal Racks. The Vise Jaws are attached to the Horizontal Racks and either or both Jaws move inward to provide the proper quadding function. When the Slide Block and Vertical Racks descend, the Jaws open outward and return to their original position, ready for the next line.

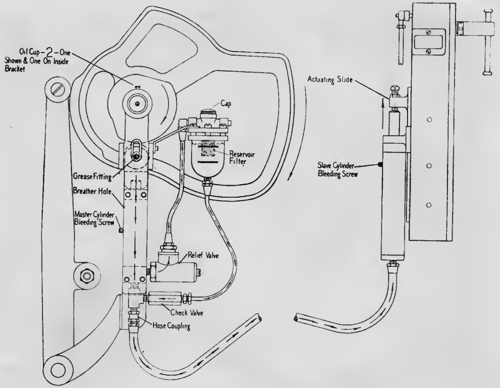


Fig. 8 Side View of Selectro-Matic Hydraulic Actuating Mechanism

Signal Lights

Selector

If the GREEN (Pump Stop) light fails to show, though switch is "ON," it will indicate that one of the following is to be checked:

1. The Bulb
2. Power from the Master Control Box or Transformer.
3. The Pump Stop Switch on top of the Selector Box.

If the RED (Cast) light fails to go on and off with each cast, check the following:

1. The Bulb
2. L.H. Vise Jaw Switch
3. Solenoid

See the Electro-Pump Stop section of the Manual, for more details.

Master Control Box Pilot Light

This light goes on with the Main Switch next to it. If the light goes out with the switch in "ON" position, it will mean either that the bulb is burned out, or that the power line is no longer feeding current to the quadder.

Transformer

When all signal lights except the one on the Master Control Box fail it will indicate that the Transformer needs replacing.

If All Lines Fail to Cast

Press the Switch Operating Rod (10) on the L.H. Vise Jaw. If a click results and the red light on the Selector Box comes on, it will indiate the Safety Switch needs adjustment. The adjustment instructions will be found below under the heading "The Electro Pump Stop Safety." (Fig. 10)

If the red light comes on and there is no click from the Pump Stop, it will indicate the Solenoid is burnt out, or there may be loose connections on the twist-lock plug.

If a buzz is heard when the Vise Jaw Button is pushed in, it will indicate that any of the following may be wrong:

1. The Solenoid Arm may be improperly seated because of dirt.
2. The Stop Lever may be improperly adjusted so that it pulls arm out too far.
3. The Pump Stop Bracket may be loose on the column.
4. The Pot Pump Lever Cam Roll (BB-31) may have a flat spot on it causing the Stop Lever to bind.

Fig. 9 Selectro-Matic Push-Button Box

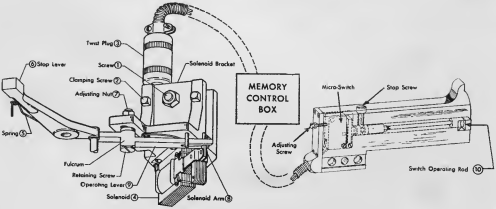


Fig. 10 Left-Hand Vise Jaw Safety Components

The Electro Pump Stop Safety

Adjustment of the L.H. Vise Jaw Safety Switch

Bring the Left Hand Vise Jaw to the Right Hand Vise Jaw. Holding it tight against the R.H. Jaw, loosen the Lock-Nut and turn Adjusting Screw in until the Pump Stop

clicks and the red light on the Selector Box goes on. (Fig. 10)

Be sure not to turn the Adjusting Screw in too far as it will cause the Pump Stop to stay open. If the red light stays on after pressure is released on the L.H. Vise Jaw, it will indicate adjustment has gone too far.

If Line Fails to Quad

If only Left Flush or Right Flush lines fail follow Steps 2, 3, 4, 6 and 7 as listed below. If the Center operation is included in the failure, begin with Step 1 and follow through until the cause of failure is found.

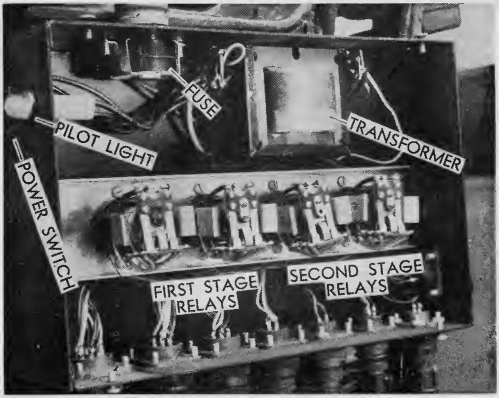


Fig. 11 Master Control Box, Selectro-Matic Quadder

Step 1. POWER. The green light on the Signal Box indicates that current is coming to the box and the Pump Stop Circuit. If it is out, check the Pump Stop Switch next to it, and see that it is in "ON" position. Next check the Control Switch on the side of the Selector Box, to make sure it is in quadding position. All being in order up to this point, go back to the Master Control Box and check in order: The Power Switch and the Signal Light which tells if the power supply is coming to the quadder; the power supply connections (plug and receptacle) to see if they are not loose or defective; and finally the Fuse to see if it is burnt out. If nothing wrong is found in this area, proceed to the next step.

Step 2. SHORT LINE SWITCH: Make sure the Short Line Adjustment is at the correct position on the Scale, so that the Trip Rod is not cancelling the quadder signals.

Step 3. THE MEMORY TRANSFER UNIT: The trouble may lie in the maladjustment of the Switches in the Memory Transfer Housing either due to the accidental hitting of the Housing or through some other cause, such as lack of lubrication.

Remove the Memory Transfer Housing from the keyboard. See Fig. 12. Then check the adjustment of the Switches as follows:

(a) The Switches should be closed when the rollers are on the high point of the Actuating Rod. Slowly depress the Actuating Rod Button and listen for the

click of the switch as the roller reaches the high point of the rod. If you do not hear the click of the switch proceed to the next step.

(b) Each switch is fastened by two Screws, one screw through a round hole and one screw through a slotted hole. Loosen both screws approximately 1 to 1½ turns. Snugly retighten the screw which goes through the round hole. Depress the button of the Actuating Rod until the Roller of the Switch is on the high point of the rod. Then move the switch in towards rod. When it clicks, tighten the screws. Check the adjustment as in step a.

NOTE: There are two types of switches

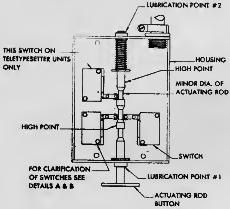


Fig. 12 Memory Transfer Unit (Transfer Switch)

in use in these Memory Transfer Units. One type has a controlled over-travel feature. This type of switch is supplied whenever a switch replacement is required. The two switches are interchangeable.

(c) When depressing the Actuating Rod, watch to see if it returns to its outer position freely. If it does not return freely, it will indicate the switches are probably set too close. This is assuming that the Actuating Rod has been lubricated.

(d) When all the adjustments have been checked and made, if necessary, replace the Housing Unit with great care. Watch for pinched wires, or wires which are rubbing against the Actuating Rod. This is of vital importance.

Step 4. RELAYS: Remove Master Control Box Cover. See if screws in Relays are tight. Push the Center button in on Selector Box. Transfer the signal by hand and see if Relays are operating in the Master Control Box. If either one or both do not operate, test further by pushing the contact leaves in by hand. If then they fail to operate, the Relay Clearing Switch may be at fault; proceed to the next step.

Step 5. RELAY CLEARING SWITCH: Remove the Cover of the Relay Clearing Box in the rear of the Hydraulic Actuating Unit. Be sure the Operating Lever is not binding in the cover slot. Push the Operating Lever in to actuate the Switch. If the Switch fails to click replace it.

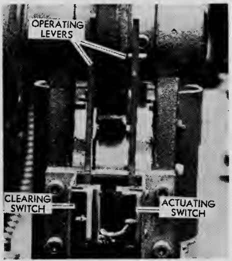


Fig. 13 Selectro-Matic Clearing and Actuating Switches

If Switch is operating and the Lever is free in slot, then revert back to the Relays in Master Control Box. Try a new relay. If the trouble is not cleared up at this point, go on to the next step.

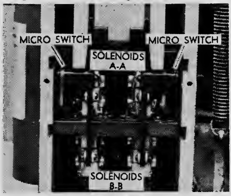


Fig. 14 Selector Operating Levers and Solenoids (Selectro-Matic Quadder)

Step 6. SELECTOR SWITCH: Remove the plate and withdraw the Switch from the Selector Box. The leads are easily pulled apart. Fig. 9.

Put the three leads together and push in the Memory Transfer Button. If a Center operation results, it will indicate the Selector Switch needs replacing.

If, after all of the above procedure, the line still fails to quad, proceed to check:

Step 7. SELECTOR OPERATING LEVERS: Remove the lower cover in the Quadder Housing. Either one or both of the Operating Levers and may be found behind the pins of the Engaging Pawls If only Right Flush or Left Flush lines are obtained, one of the Levers will be out of position; if Centers only can be obtained, both Levers will be found disengaged.

Adjustment

Lift the Sliding Block and the Actuating Slide in back simultaneously. Push either or both Levers into position so the fork of each is engaged in the pins of the Slliding Block as you let it down.

If Spacebands Justify During Quadding Operation

These are the possible causes, to be checked by removing the lower cover of the Quadder Housing.

1. LOSS OF CONTACT WITH MICRO-SWITCH

   The Operating Lever Extension may be bent outward, or the Operating Lever may be moving out as the Sliding Block begins to rise. In either case contact will be lost with the Button of the Micro-Switch, causing interruption of current to the Justification Stop Solenoid which actuates the Justification Stop Lever to stop Spaceband drive.

   If the Operating Lever Extension is found bent, it must obviously be straightened carefully to restore contact. But if the Operating Lever is coming out as the Sliding Block rises, it will mean that the Retaining Spring has lost tension against the Lever. Remove the Plate which holds the Spring. Stretch out the spring until satisfactory tension is obtained.

2. A MICRO-SWITCH OR SOLENOID MAY HAVE FAILED

   If Spacebands are driving up on a "Right Flush" signal it will generally indicate that the Solenoid, or Micro-Switch on the left side of the Solenoid and Switch Frame has failed.

   Spacebands driving up on "Left Flush" signals will mean that the Micro-Switch or Solenoid, on the right side has failed.

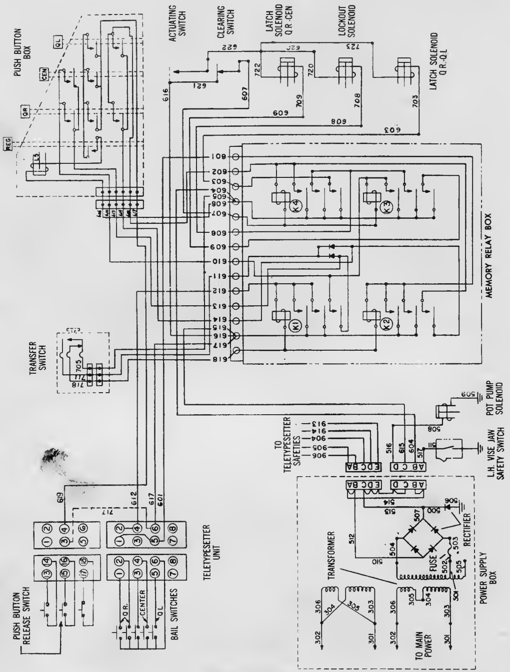
3. JUSTIFICATION STOP SOLENOID.

   When Spacebands justify during all three quadding operations, it will mean the Justification Stop Solenoid has failed.

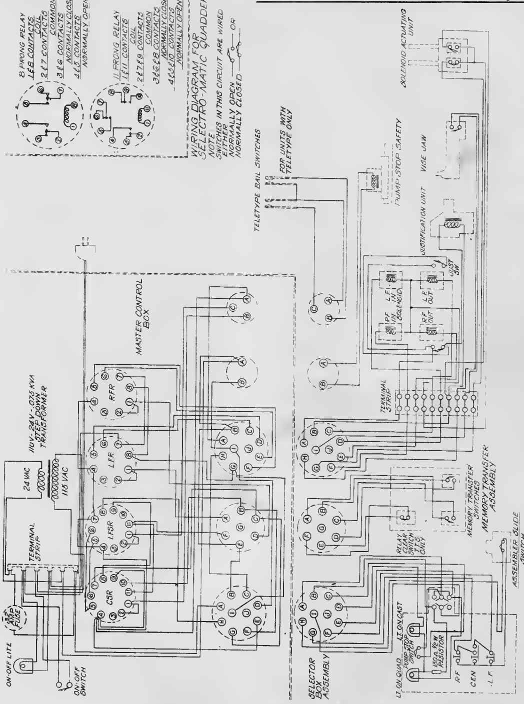
If Lines Fail to Cast

Check the following:

1. Power source. Examine plug and connections.
2. Pump Stop Switch on top of Selector Box. ("On" and "Off").
3. Micro-Switch in Left Hand Vise Jaw.
4. Pump Stop Solenoid.
5. Examine Spacebands and make sure they are clean and sliding freely.



Schematic Circuit Diagram, Electrically Controlled Hydraquadder



Schematic Circuit Diagram, Selectro-Matic Quadder

Selecto-Spacer

HOW IT OPERATES

The Selecto-Spacer is a device used for the purpose of automatically inserting the thin and en spaces needed to justify a line, with a signal given by the perforator operator at the end of each line, instead of the perforator operator having to add these extra spaces in the usual manner. Tape punched for the Selecto-Spacer, will have extra returns at the end of each line where thin or en spaces are needed. For thin spaces there will be two returns at the end of the line plus the elevate signal. For en spaces, there will be 3 returns, plus the elevate signal at the end of the line. These extra returns will cause either thin of en spaces to be put in the line along with each spaceband, automatically.

The Selecto-Spacer consists primarily of a tape reader, a two stage memory system, a sequence unit, a switch and cam mounted at the front end of the teletypesetter operating unit elevate shaft, and a switch in front of the keyboard bell-crank lever for the spaceband. The two solenoids located on the bar back of the keyboard weights operate either the thin or the en space providing there has been a signal for that space. The Selecto-Spacer reads tape at 960 signals per minute, and remembers the number of return signals at the end of each line.

When a line of tape has just the regular return and elevate signal, this causes the Selecto-Spacer to stop reading tape, several signals after this return signal has been sensed.

The Selecto-Spacer now waits until the teletypesetter operating unit has finished the line ahead of it, and elevates that line. As it elevates the line ahead, the cam operates the switch under the front end of the elevator shaft and causes the Selecto-Spacer to start reading the next line.

We will assume that the line now being read by the Selector-Spacer, has two returns plus the elevate signal at the end. The first return signal starts the time delay unit. The second return signal puts a memory in the counting relay for thin spaces to be added to this line. When the line ahead of this is elevated, and the elevator switch is closed, it causes the sequence unit to operate, transferring this second return signal to the thin space holding relay. Then, as this line is assembled, and the spaceband switch is closed, it will cause the thin space to drop with each spaceband. Should there have been 3 returns at the end of this line the first return signal would have done its job of starting the time delay unit. The third return signal would have cancelled the second one and set up the memory for en spaces to be dropped between each word in the line.

THE SEQUENCE OF OPERATION

See Illustration No. 6.

The Selector-Spacer functions from only one signal, the return signal. When using the Selecto-Spacer, according to what space is needed in the line, either one, two, or three return signals are used.

One return signal at the end of the line starts the Time Delay unit into operation, which will stop the tape from reading, after it has run approximately nine holes beyond the return signal.

Two return signals will cause thin spaces to be added to the line. Three return signals will cause en spaces to be added to the line.

As the return signal is read, the number four pin is in the up position. Each time this occurs, the Selector Lever sets up a key combination on the opposite end. This allows the transfer lever to travel toward the left and close the transfer switch. Each time the transfer switch is closed it generates one electrical impulse. These impulses are registered and retained in the counting relay. The counting relay is stopped-off so that a maximum of only three impulses can be recorded. This is a safety measure in case the perforator operator should accidentally strike more than three return signals at the end of a line. These impulses, whether one, two, or three, are retained in the counting relay while the line ahead of this is being assembled.

As mentioned before, the first return signal causes the time delay unit to actuate, thus stopping the tape, after an over run of approximately nine signals, so at this point the Selecto-Spacer will stop, and remain stationary until the line ahead of this, which is being assembled, is completed.

When the line in the Teletypesetter (1 line ahead of the Selector-Spacer) is completed, the elevate signal closes the elevator switch. This starts the sequence cam. See Illustration No. 6.

The functions of the sequence unit are as follows:

OPERATION A: The cam leaves the No. 1 switch position. This closes No. 1 switch which will lift the solenoid stop and start the motor drive on the cam.
This remains closed until the cycle is completed.

OPERATION B: Cam switch No. 2 is opened momentarily, this breaks the holding circuit in the thin and en relays. This action wipes out any space signal or memory for the line which just finished in the Teletypesetter.

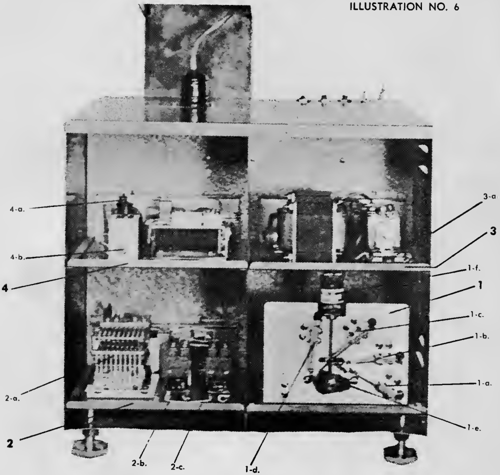
OPERATION C: Cam switch No. 3 is closed momentarily. This action converts the count in the counting relay into a memory, i. e.
One Count, Neither relay is closed.

Two Counts, Thin relay is closed.
Three Counts, En relay is closed.
When either relay is closed, it will remain so until the next sequence cycle.

OPERATION D: Cam switch No. 4 is closed momentarily. This releases the counting relay, and also starts the Selectro-Spacer to read the next line.

OPERATION E: This cam continues to revolve after leaving No. 4 switch position, on to its starting position. When it reaches its starting position it opens No. 1 switch. When No. 1 switch is open it will stop cam drive motor and release the solenoid safety stop pin. This will hold cam in start position ready for the next cycle.

ILLUSTRATION NO. 6



1. Sequence Unit
   - 1-a. Sequence Unit Motor Switch #1
   - 1-b. Sequence Unit Memory Release Switch #2
   - 1-c. Sequence Unit Transfer Switch #3
   - 1-d. Sequence Unit Counting Relay Release Switch #4
   - 1-e. Sequence Cam
   - 1-f. Sequence Unit Solenoid
2. Control Rack
   - 2-a. Counting Relay
   - 2-b. Thin Space Relay
   - 2-c. En Space Relay
3. Power Rack
   - 3-a. Fuses
4. Time Delay Rack
   - 4-a. Transistor
   - 4-b. Tape Control Delay Adjustment

TIME DELAY UNIT

The purpose of the time delay unit is to stop the tape, and keep a loop of tape between the Selecto-Spacer and the Teletypesetter. The way it functions is as follows:

When the Counting Relay receives the first impulse (regardless of whether 1, 2, or 3), it starts the time delay unit into action. It will delay tape from stopping until approximately nine holes of tape have run out from the first return signal back to selector pin. It will again start tape when Operation D takes place in the sequence. At this time the counting relay is released. Basically the first Counting Relay armature upper switch controls this action.

We will assume for illustrative purposes, that there were two return signals in the line just read. The first signal, of course, started the time delay unit to work, which stops the tape from reading. The second signal set up memory for thin spaces to be added to the line, and as the sequence unit makes its revolution, it transfers this signal from the Counting Relay to the center relay in the Control Rack, which holds a circuit closed between the spaceband switch and the solenoid, back of the keyboard, to release the thin space each time the spaceband key is operated during the assembling of this line.

As this line is being assembled and thin spaces added between each word the Selecto-Spacer Selector Head is reading the following line, and any space signalled at the end of that line, will be stored in the Counting Relay, to again be transferred over to one of the Holding Relays as this line is elevated to the casting mechanism.

SEQUENCE UNIT SWITCH ADJUSTMENT

Too much tension at this point will cause an undue amount of starting torque to be reproximately 1-32" after it bumps this plunger.

See Illustration No. 6.

In referring to these contact stacks we start with No. 1, which the cam is holding open in its stopped postion, and then go around the rotation of this cam counter clockwise. The No. 1 Switch should have enough tension that it will hold closed after the elevator switch has made its momentary contact, and cause this sequence clock to make a complete revolution. When this No. 1 spring tension is set correctly, and the clock sequenced by pressing the release button, it will roll around a complete revolution then either just bump the stop pin plunger and stay there, or rock back apquired when the elevator cam switch closes, therefore, you can see that if there were too much tension on this spring, the unit would fail to sequence after each line and the TTS Operating Unit would run on, thus tearing the tape. The No. 2 switch should separate approximately 1-32" to 3-64" as the high part of the cam travels under the cam rider at the end of this switch. It requires this much separation to allow the holding relays in the memory panel to release. If this gap is not enough, you will find that even though a space was not called for by one or two extra return signals, the line will get thin or en spaces if these signals had been in for the previous line, due to the holding relays failing to release. This No. 2 switch also must have enough pressure after the cam travels beyond it, that it will hold a firm contact so that when the cam passes the No. 3 switch to transfer from the Counting Relay to the Thin or En relays, these relays will close and stay closed. If this tension is too much, it will retard the turning of the sequence cam. If it is too light, these relays will fail to hold the memory, once it has been transferred. The No. 3 switch should travel approximately .020" after the points are closed by the sequence cam moving by this switch. This will give a good contact to transfer any memory held in the Counting Relay, to either the Thin or En relay. Should this travel not be great enough, or these points of No. 3 stack be slightly dirty, a memory picked up by one or two extra signals in the Counting Relay, will fail to transfer and lock in either the thin or the en space relay.

Now as this cam passes the No. 4 switch, it should close the points, and cause them to move approximately .015 to .020". The action of this switch is to reverse the current on the coil of the Counting Relay, and the tape feed will start again, reading the next line.

ELEVATOR CAM SHAFT, CAM AND SWITCH

See Illustration No. 7.

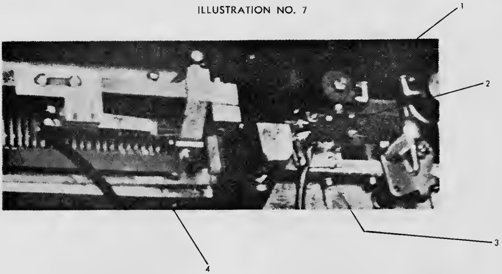
The fiber cam is placed on the front end of the Elevator cam shaft, by means of the screw which holds the adjusting plate for end play. This cam should be turned, so that when the teletypesetter operating unit is in its normal position, the high point on this cam will be pointing to the right of the machine.

The microswitch, which is located directly under this cam, must be so located on the front frame of the teletypesetter operating unit so the little roller on this microswitch clears the cam by approximately 1-32", when the operating unit is in its normal position. With the switch located in this position, place an elevator signal over the teletypesetter operating unit, revolve it by hand, and note that the plunger of this microswitch makes full travel, so a contact will be given to the sequence unit, to start it in operation.

SPACEBAND SWITCH

There are two styles of Spaceband Switches used with the Selecto-Spacer. One style for a machine which does not have an Electronic Mat Detector on it, and another style of switch for machines that are equipped with the Electronic Mat Detector.

ILLUSTRATION NO. 7



1. Elevator Shaft Cam
2. Elevator Shaft Switch
3. Elevator Shaft Switch Mounting Plate
4. Spaceband Switch

When the Selector-Spacer is used on a machine not equipped with an Electronic Mat Detector, a special bell crank lever for the spaceband is furnished with the Selecto-Spacer. To insert this bell-crank lever, the bell crank lever assembly must be removed from the machine. The two clamping screws at either end of the fulcrum rod that the bell-crank levers rest on, should be driven with a pin punch to the left, enough to allow the spaceband bell-crank lever to be lifted out, and the new style with the projection on it to operate the spaceband switch inserted. Then the fulcrum rod should be driven back to place, and clamped securely, by means of the two screws on the little clamping plate at either end of this fulcrum rod.

The Spaceband Switch for the non-Mat Detector type of machine is located on the bell-crank lever assembly, so the fiber projection at the right end of the switch, just clears the frame work casting at the right of the spaceband bell-crank lever. This switch should be so adjusted, that the contact points will have a gap of approximately .025 to .040 when the spaceband bell-crank lever is in normal position. As the spaceband bell-crank lever moves to depress the spaceband key, it should close the Spaceband Switch points and cause an over travel of approximately .005 to .010. Failure to close the points, and have enough over travel after they close, will often cause the failure to insert a thin or en space. If these points travel too far after closing, it will cause undue fatigue on the contact blades, and they will break sooner than they normally should.

On the machines equipped with the Electronic Mat Detector, a hole is drilled into the right hand of the keyboard contact bar of the Electronic Mat Detector, and the Spaceband Switch mounted so the tip of the fiber on the back plate, is exactly in front of the spaceband bell-crank lever at its lower end. There must be a clearance between the rocking bar of the keyboard contact bar of the Mat Detector, also clearance between this switch, and the casting of the bell-crank lever assembly, at the right side of the spaceband bell-crank lever. The back blade of this switch, should be so adjusted that it just fails to rest against the keyboard contact bar, in its unoperated position. The front point should be adjusted, so that when the bell-crank lever for the spaceband is at its extreme travel, it will close these points, and have an overtravel of approximately .005 to .010. See Illustration No. 7.

THE SOLENOID LIFTS AND BAR ASSEMBLED

The bar holding the solenoids which lift either the thin or en space weights at the back of the keyboard, thus operating either the thin space or en space cam, is mounted on the lower screws of both the left and the right hand keyboard cam frame supporting posts. The holes at either end of the solenoid bar are elongated. When placing this bar on the machine, it should be so positioned, that the lift levers will exactly center under the thin and

en space weights. It is seldom necessary to check both weights, as they are at a fixed distance, and the solenoid lift levers are also fixed at the same distance apart. Therefore in positioning this bar, when you have the keyboard swung out, strike the en space key and then position the bar so the solenoid lift to the left side of the keyboard, is exactly under the center of the weight for the en space. After this bar has been positioned and the screws tightened, press the en space button on the main control panel of the Selecto-Spacer, then close the spaceband switch manually. You should note the lifting of the weight for the en space. Now press the release button and after allowing about a second for the sequence unit to revolve, press the button marked "T" for thin space, then operate the spaceband switch manually, and note that the cam for the thin space switch is tripped. If both of these cams do not trip on this test, check again, for the proper horizontal position of the solenoid lift bar.

POWER REQUIREMENTS

The Selecto-Spacer uses 115 Volts alternating current for its initial power. Only a few of the spacer's components operate on 115 VAC, however. In the power rack we have a transformer with 2 secondaries. One of these reduces the voltage to 6 VAC which operates a majority of the components. The other transformer secondary produces 48 volts which is then rectified. So we are using 115 VAC, 6 VAC and 48 VDC to operate the Selecto-Spacer. Total current consumed is about 1½ amperes.

115 VAC—Used to operate the reading head motor and the sequence cam motor and its solenoid stop. 115 VAC also passes through the NO contacts on Relay No. 1 and through sequence cam switch No. 1.

6 VAC—Used to operate the tape control solenoid in the reading head and the thin space and en space solenoids which are mounted on the rear of the keyboard. 6 VAC is also used to energize the coils of relays No. 1, No. 2, No. 4 and No. 5. 6 VAC passes through contacts of R2, R4, R5, counting relay, R6 and through No. 2 and No. 3 sequence cam switches. (R1 and R2 are not shown in illustration No. 6. They are located near the sequence cam motor in the sequence rack.) The following switches are in the 6 VAC circuits: spaceband, tight tape, elevate, tape stop, en, thin, release and auxiliary tape control (if used).

48 VDC—Used to energize the coils of the counting relay and the time delay relay (R6). 48 VDC passes through the transfer switch in the reading head, through sequence cam No. 4, contacts of R2 and of the counting relay.

DETAILED SEQUENCE OF OPERATIONS

(See Wiring Diagrams)

First, let us assume we are running tape which has only one return per line through the Selecto-Spacer and operating unit. If the Selecto-Spacer is plugged into a 115 VAC outlet and the motor switch is in the on position, the reading head motor will run continously. Also, if the counting relay is in its normal, unoperated condition, the time delay relay, R6, will be energized. Now we insert the perforated tape in the spacer (the second line in the tape). Next we move the tape stop switch to its on position. This completes a circuit to the tape control solenoid through NO contacts of R6. When this solenoid is energized it unlatches the selector levers and the tape advances past the pins on the selector head until a return code is read. This causes the transfer switch contacts to close one time. This momentary closing of the transfer switch sends a pulse of current through one winding of the coil of the counting relay. The resulting magnetic field will pull the No. 1 lever in to the relay core. When this No. 1 lever is pulled in it opens a NC contact of the counting relay. This is the contact which controls energizing of R6 so we open this circuit. However, R6 will remain energized for a short time (about ½ second or long enough for the tape to feed 8 or 9 more codes) due to discharge of capacitors in the circuit. After this short time delay R6 will be de-energized. This allows contacts of R6 to open breaking the circuit to the tape control solenoid. As a result the selector levers are again latched stopping the tape from advancing. Now the operating unit finishes reading its line of tape (one line ahead of the spacer) and elevates. As the TOU elevate shaft turns a cam attached to its front end closes the elevate switch. Closing of the elevate switch completes a circuit through the coil of R1. Energizing R1 closes its contacts making a circuit through the sequence cam motor and the sequence cam solenoid stop. The solenoid pulls the stop out of the path of the cam and the motor starts to turn the cam. The elevate switch is only closed for a short time and then opens de-energizing R1. During the short interval that R1 is energized the cam motor turns the cam enough to allow cam switch No. 1 to close. Now cam switch 1 holds the circuit to the cam motor and solenoid after R1 has been released. The cam motor continues to turn the cam opening the NC cam switch No. 2. This action produces no effect at this time. Now cam switch No. 3 (NO) is closed. Again nothing happens. Next NO cam switch No. 4 is closed by the rotating cam. This switch completes a circuit through the second winding of the counting relay coil. This pulse of current is traveling in the opposite direction from the current mentioned earlier. Due to this

opposite current flow the magnetic field now has reversed polarity from the previous field. This repels the No. 1 counting relay lever forcing it away from the coil core. (This is possible because the counting relay levers are permanently magnetized and the magnetic field will not change their polarity.) When the No. 1 lever is repelled its contacts are allowed to close again energizing R6. This results in the tape control solenoid being energized again and tape starts through the reading head once more. Immediately after this No. 4 switch is closed momentarily, cam switch No. 1 is opened. This breaks the circuit to the sequence cam motor and it stops running. Also the solenoid releases its stop to prevent the cam from coasting past its normal stopping place.

This line of tape now passes through the TOU while the spacer reads the succeeding line. Each time the TOU makes a selection for a spaceband the TOU bell crank closes the spaceband switch but we get no response due to the unoperated condition of R4 and R5.

Thus we see that when each line in the tape contains but one return signal we get several operations in the spacer even though no extra spacing is added to the line as it is assembled.

Now let us suppose that the next line to be read by the spacer has 2 return codes. When the first return code is read the result is the same as before. The transfer contacts make a momentary contact which sends a pulse of current through the counting relay pulling in its No. 1 lever which breaks the circuit to R6, the time delay relay. The delay circuit will again hold R6 closed for 8 or 9 codes. Now the second return code is read allowing the transfer switch to close momentarily again. This sends another pulse of current through the coil of the counting relay. This time the No. 2 lever of the counting relay will be pulled to the relay core. When this No. 2 lever is pulled in its NO contacts will be closed. Now the spacer finishes reading its 8 or 9 extra codes. R6 is de-energized. Opening of contacts of R6 breaks the circuit to the tape control solenoid, the selector levers are again latched and the tape stops feeding. (The spacer always finishes reading a line before the TOU reads the previous line because the spacer reads at 1½ times the speed of the unit). Now the TOU finishes reading the previous line and elevates. When the elevate switch closes R1 is energized and its contacts complete a circuit to the sequence cam motor and solenoid stop. The stop is pulled out of the path of the sequence cam and the cam starts rotating. As this cam turns it allows cam switch No. 1 to close maintaining current to the cam motor and solenoid after R1 is de-energized when the elevate switch is released. Now the rotating sequence cam opens the NC, No. 2 cam switch. Again this does nothing. Next NO cam switch No. 3 is closed. Closing cam switch No. 3 now completes a circuit to the coil of the thin space relay, R4, through a NC contact of the No. 3 counting relay lever and a NO contact of the No. 2 counting relay lever. Cam switch No. 3 is closed only for a short time but when R4 is operated it will be kept energized by a circuit through its own NO contacts, cam switch No. 2 and NC contacts of R2. Cam switch No. 4 is now closed sending a reverse current through the counting relay. This repels the No. 1 and No. 2 levers which had been pulled in. Again a contact of lever No. 1 energizes R6 and as a result tape starts feeding through the reading head.

Now we will assume that the next line of tape being read has 3 return codes and at the same time the line which had 2 returns is feeding through the TOU. Remember we just left R4, the thin space relay, energized. Now as the operating unit runs the line of tape containing the 2 return signals we will complete a circuit each time a s p a c e b a n d is selected. When the spaceband switch closes a circuit is closed to the thin space solenoid through NO contacts of R4. As long as R4 remains energized a thin space will be released with each band.

While the TOU has been running the line of tape with 2 returns and adding thin spaces, the spacer has read the next line containing 3 return codes. When the spacer reads the 3 returns the transfer switch is closed 3 times. The results are the same as when 2 returns were read except that the No. 3 counting relay lever is also pulled in changing the condition of its contacts.

Now the TOU elevates the line to which thin spaces were added. Again the elevate switch causes the sequence cam to turn. Cam switch No. 1 closes to keep the cam turning. Now cam switch 2 is opened. As cam switch No. 2 was in the holding circuit to the coil of R4 this allows R4 to open. Next cam switch No. 3 is closed for a short time. This closes a circuit to the coil of the en space relay, R5, through a NO contact of the No. 3 counting relay lever. When cam switch No. 3 opens R5 is held energized through its own NO contacts, cam switch No. 2 and NC contacts of R2. Next cam switches No. 4 and No. 1 are operated giving the same results as before.*

Now this line of tape containing 3 return codes is fed on through the TOU. Each time a spaceband is selected the spaceband switch is closed momentarily. This energizes the en space solenoid through NO contacts of R5. R5 is released by cam switch No. 2 the next time the sequence cam rotates.

*The counting relay levers are pulled in one at a time due to the mechanical construction of the relay. However, when current is reversed through the counting relay coil, all levers which have been pulled in will be expelled simultaneously.

AUXILIARY CONTROLS

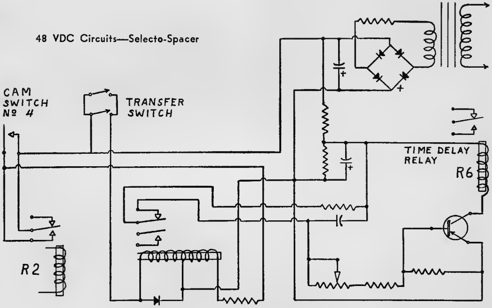
The foregoing operational explanation was based on normal, uninterrupted operation. For non-normal operations there are 3 push button switches mounted on the spacer and the tight tape switch located between the spacer's reading head and the selection mechanism of the TOU. Their functions are as follows:

Thin and en push buttons—Energizes R4 or R5. When button is released relays are held closed through their regular holding circuits. If both buttons are pushed down thins and ens will both be inserted with each spaceband. These relays will be released the next time the sequence cam opens cam switch No. 2.

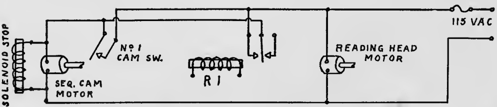
Release push button and tight tape switches—These two switches are wired in parallel and have exactly the same effect on the spacer. Closing either one of these switches will energize the coil of R2. As the NC contacts of R2 are opened R4 and-or R5 are released if they are energized. One set of NO contacts of R2 send a reverse current to the coil of the counting relay, expelling the levers that have been pulled in. This allows tape to start feeding. The second set of NO contacts of R2 make a circuit to the coil of R1 to start the sequence motor. R2 has no holding circuit so it remains energized only as long as one of these switches is held closed. The purpose of these switches is to erase any count or memory either manually or by tape becoming tight.

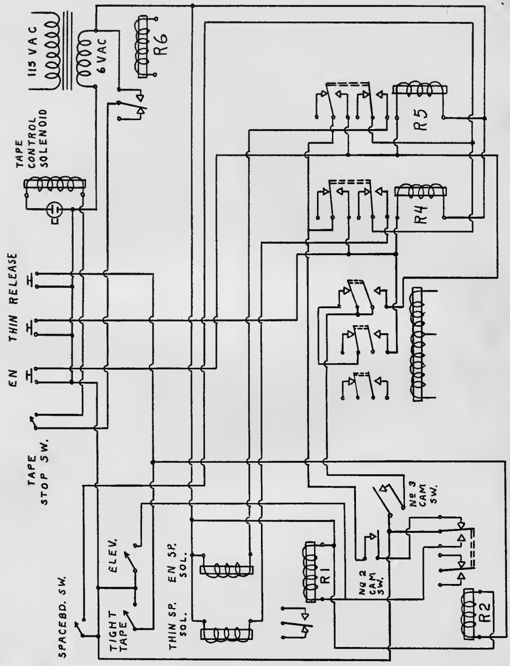
Auxiliary Tape Control Switch—We use this switch on machine T9 in the OPUBCO composing room. If tape feeding into the Selecto-Spacer becomes tight this switch will open the circuit to the tape control solenoid causing tape to stop feeding immediately.

48 VDC Circuits—Selecto-Spacer

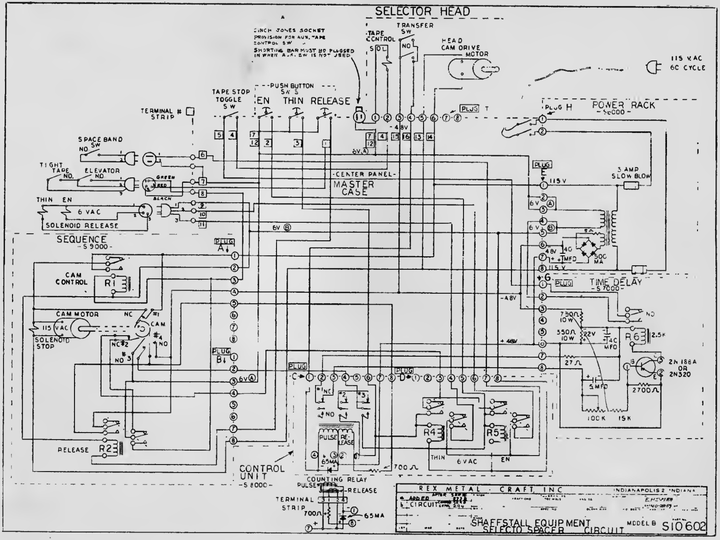


115 VAC Circuits—Selecto-Spacer





6 VAC Circuits—Selecto-Spacer



SELECTOR HEAD
CINCH JONES SOCKET PROVISION FOR AUX. TAPE CONTROL SW
SHORTING BAR MUST BE PLUGGED IN WHEN AUX. SW IS NOT USED
TAPE CONTROL SOL
TRANSFER SW NO
HEAD CAM DRIVE MOTOR
115 VAC 60 CYCLE
PLUG T
PLUG H
POWER RACK -S6000-
TAPE STOP TOGGLE SW
PUSH BUTTON SW'S
EN
THIN
RELEASE
TERMINAL # STRIP
SPACE BAND SW NO
TIGHT TAPE NO.
ELEVATOR NO
GREEN
RED
BLACK
THIN EN
6 VAC
SOLENOID RELEASE
-48V
6V Ⓐ
6V Ⓑ
-CENTER PANEL-
MASTER CASE
PLUG E
115V
3 AMP SLOW BLOW
500 MA
4C
1MFD
115 V
48V
SEQUENCE -S9000-
PLUG A
CAM CONTROL
R1
CAM MOTOR
115 VAC
SOLENOID STOP
CAM
NC #1
#4 NO
NC #2
NO #3
PLUG B
RELEASE
R2
PLUG G
TIME DELAY -S7000-
-48V
+48V
NO
750Ω 10W
550Ω 10W
22V
4C MFD
R6
2.5K
27Ω
5MFD
2N188A OR 2N320
2700Ω
100K
15K
PLUG C
PLUG D
#1 NC
NO
#2
#3
PULSE
RELEASE
65MA
700Ω
R4
R5
THIN
6 VAC
EN
CONTROL UNIT -S8000-
COUNTING RELAY
PULSE
RELEASE
TERMINAL STRIP
700Ω
65MA
REX METAL CRAFT, INC
INDIANAPOLIS 2 INDIANA
ADDED
CIRCUIT
SHAFFSTALL EQUIPMENT
SELECTO SPACER CIRCUIT
MODEL B
S10602

Vacuum Tubes and Photo-Cells

Thomas Edison is credited with discovering the underlying principles of the vacuum tube in 1882. But Edison came upon the discovery while experimenting to improve his incandescent lamp and apparently attached small importance to it. It was some 20 or more years later that the British scientist Fleming built the first vacuum tube and demonstrated practical uses for it. From this chance beginning, the vacuum tube has become so widely used that today there are more than 1200 sizes and types available.

Most of these tubes can be classified in two groups: high vacuum and gas-filled tubes. Or they may be arranged in four groups according to the number of their elements, as: diodes, triodes, tetrodes and pentodes. Sometimes they are grouped according to their cathodes, as: directly heated cathodes, indirectly heated cathodes and cold cathoes. But however they are classified, there is a tube for every purpose that has been devised for one. Before taking up the specific types used in composing room equipment, we will examine the basic principles on which all electronic tubes work.

The simplest form of vacuum tube is the diode with directly heated cathode. It consists of a filament of high-resistance wire or ribbon (similar to the filament of an incandescent lamp) and a plate or anode. These elements

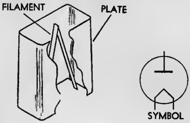


Fig. 1

are suitably mounted in a glass bulb from which the air has been exhausted. Arrangement of the elements and the symbol for the tube are shown in Fig 1. If this tube is connected into a circuit as shown in Fig. 2, current flowing through the filament from battery A will heat the filament to incandescence. This heat will cause the filament to throw off free electrons which will form in a sort of miniature cloud surrounding the filament. This action of throwing off electrons is known as "thermionic emission".

As the electron cloud grows, its negatively charged particles repel each other and they also repel additional electrons attempting to leave the filament. This repelling force is called "space charge". A point will be reached where the repelling force of the space charge balances the emitting action of the heated filament, and the condition will become static. Now, if the voltage from battery A is raised, causing more current to flow and increasing the temperature of the filament, more electrons will leave the filament until a new balance of forces is reached, and, likewise, if the voltage is lowered, reducing current and temperature, the repelling force of the space charge will force some of the electrons back into the filament, reducing the size of the cloud and establishing a new balance.

So far, the effect of battery B has been neglected. Notice that this battery has its negative terminal connected to one leg of the filament and its positive terminal to the plate of the tube. Now the electron cloud consists of

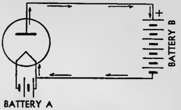


Fig. 2

negatively charged particles (electrons) and the plate has a positive charge. Since unlike charges attract each other, some of the electrons will be attracted from the cloud to the plate. This makes room for more electrons to leave the filament and enter the cloud. Electrons from the battery (B) will flow to the filament to replace those emitted into the cloud, and a like number of electrons will flow from the plate to the battery to replace those going to the filament. So a current flow is set up, flowing from battery B to the filament, to the plate and back to the battery. This current flow is indicated by arrows in Fig. 2. The voltage of battery B will influence the current flow in the plate circuit of the tube. The higher the voltage, the stronger the attraction of the plate for electrons in the cloud and the greater the current flow. The ultimate limit of current is reached when the plate is attracting all the electrons the filament can emit. Thus, two factors influence the flow of current through the tube's plate circuit: the positive voltage applied to the plate, and the temperature of the filament or cathode.

Since it is the positive charge on the plate which attracts electrons and causes current to flow, it can readily be seen that if a negative voltage were impressed on the plate no current would flow due to this negative charge

repelling the electrons in space. Thus it will be seen that current can flow in only one direction in the plate circuit. If battery B were replaced by a source of alternating current, the tube would act as a rectifier, passing current on the positive half-cycles and blocking flow on negative half-cycles. This form of rectifier is widely used in radio and television sets and other applications requiring high voltage and low current. Two sets of diode elements are commonly enclosed in a single bulb and the resulting twin diode can be connected to give full wave rectification.

In the examples discussed, the filament has served both as the source of heat and the emitter of electrons. It is a very efficient arrangement, but for many circuits in which tubes are used it is desirable to separate the filament and cathode. This is done by enclos-

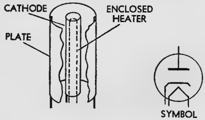


Fig. 3

ing the filament in a cylinder of some ceramic material which is, in turn, enclosed in a close-fitting sleeve of metal. The sleeve becomes the cathode and the filament serves only to heat the cathode to cause it to emit electrons. The arrangement is called an indirectly heated cathode. The construction and symbol are shown in Fig. 3.

Rectification is one of the most important functions of the vacuum tube. A second is amplification, where a very small voltage is used to cause large current changes in the plate circuit of the tube. This is accomplished

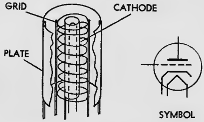


Fig. 4

by adding a third element to the diode, making it a triode. This third element is called the grid, or more properly the control grid. It is formed of a spiral of wire placed between the cathode and plate of the tube. Electrically, it is insulated from other elements of the tube and a connection is brought out to a pin on the tube base. This construction and symbol are shown in Fig. 4.

If this tube is connected as shown in Fig. 5, the control grid will be connected to the arm of a potentiometer which is connected across the battery C. The positive side of this battery is connected to the cathode. The potentiometer permits varying negative voltage on the control grid from zero to the full voltage of the battery. The plate circuit consists of the plate connected to the positive side of battery B while the negative side of the battery is connected to the cathode. The filament circuit is omitted.

In action, with the potentiometer arm set at the positive end, the voltage on the grid will be the same as the cathode, and the grid will have no effect on plate current. As the potentiometer arm is moved a little toward the negative end, a voltage that is negative with respect to the cathode, will appear on the grid, giving it a negative charge. This negative voltage is called the grid bias. This will repel electrons and restrict their travel.to the plate. The grid is of open construction and some electrons will pass through it. If the potentiometer arm is moved still farther toward negative, a greater bias will be placed on the grid and fewer electrons will slip through. As the bias is increased, the number of electrons getting through the grid decreases, and since these electrons are the plate current, the grid is controlling plate current. There is a point at

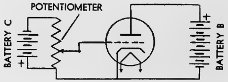


Fig. 5

which all plate current will be stopped and this is called the cut-off point. Increasing bias beyond cut-off will have no effect.

It is important to note that the mere presence of a charge is all that is needed to give the grid control of plate current. It is not necessary for current to flow in the grid circuit. It is this fact that allows the vacuum tube to amplify unbelievably small signals into useful power. It is hard to imagine the incredibly feeble power generated in a receiving antenna by a signal from a distant radio station, but it is enough to cause a tiny variation in the grid bias of a tube and this in turn can cause a relatively large change in plate current. If more amplification is needed one tube can be

coupled to another through suitable means and this amplified effect further multiplied.

We have been discussing high vacuum tubes and continuing along this line could take up the tetrode and pentode in that order. But these tubes are not used in composing room apparatus and discussing them would add little to our understanding of the tubes with which we work. It is time, then, to examine that class known as gas-filled tubes.

Considering first, the diode in Fig. 1, suppose that instead of a vacuum the bulb contained a small amount of mercury vapor or a gas like argon or xenon. When current flows from cathode to plate in this gas, the flying electrons collide with atoms of gas knocking some of the free electrons out of the gas atoms. The gas atoms now have a positive charge and are known as ions and the process creating them is called ionization. Ionization is characterized by a glow of colored light in the tube. The bulb will now be filled with a mixture of gas ions and speeding electrons, known as plasma. The space charge, which hampers the flow of electrons in the high vacuum tube, is eliminated by the positive gas ions neutralizing electrons from the electron cloud. The plasma is a good conductor and offers little resistance to the flow of electrons from the cathode to the plate. This tube therefore will operate at low voltage and can handle moderately heavy current.

Many high vacuum tubes have their counterparts in the gas-filled class and this is true of both the triode and tetrode. One name for the grid-controlled gas-filled tube is thyratron. A gas-filled tetrode is commonly referred to as a shield-grid thyratron. The presence of gas enables the thyratron to handle larger currents at lower voltage just as it does in the diode. But, when this gas becomes ionized, it nullifies the grid's control over electron flow. Compared to the smooth, continous control of the grid in a high vacuum tube, the action of the thyratron's grid is more like the trigger of a gun, and once the tube is fired, the grid is powerless to stop or control conduction. A brief description of how the thyratron works will explain why this is so.

At the start, with a sufficiently high negative bias on the grid, all electrons emitted by the cathode will be repelled by the grid and plate current will be cut off. As bias is lessened a critical value of grid voltage will be reached at which all the electrons in the cloud around the cathode are no longer repelled by the grid. The change is not gradual as it is in high-vacuum tubes but comes suddenly and the released electrons cause almost instant ionization of the gas in the bulb. The tube is said to "fire" or "blow" and the critical grid voltage at which firing occurs is the "firing point". Now gas ions have a positive charge and the control grid, being negative, will quickly attract enough ions to neutralize its effect on electrons passing through the grid opening. Ionization will be maintained and the tube will conduct as long as the plate remains positive. If the plate becomes negative, it will no longer be able to attract electrons, the tube will cease to conduct and deionization will occur. If negative grid bias is raised above the firing point before plate voltage is restored, the tube will be conditioned to repeat the cycle.

In detail of construction, the thyrathon differs considerably from the high vacuum variety. The cathode and plate are proportioned for greater emission and current handling but the most striking difference is in the grid construction. Consider the shield-grid thyratron of which the 2050, 2051 and the 2D21W (all used in our composing room) are examples. The shield grid is a sheet metal structure almost completely enclosing the cathode and the plate. Inside this structure there are two partitions, one near the cathode, one near the plate. Each partition has an opening near its center through which the electron stream must pass from cathode to plate. Centered between the openings in the partitions is the control grid, a small element shaped like a washer or a ring. In use the shield is connected at or near cathode voltage. Its purpose is two-fold: 1, to prevent electrons from the cathode reaching the plate by any route other than through the holes in the partitions; 2, protect the control grid from heat and contamination from the cathode. The control grid, thus protected, is very sensitive and responds to voltage variations obtained from photo-cells, resistance-type temperature probes, etc. The symbol is shown in Fig. 6.

So far, all tubes discussed have heated cathodes and depend on the cathode emitting electrons for operation. There is another class known as cold cathode tubes which oper-

Fig. 6

Fig. 8

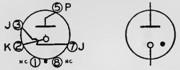
ate without thermionic emission. Cold cathode tubes are gas-filled with a mixture of argon and neon or argon and helium. The OC3 and the OA4G are examples of this class.

The OC3 is a diode used as a voltage regulator. Its cathode is a thin vertical metal rod supported inside a thin-walled metal cylinder, which is the anode or plate. Properly connected into a circuit, so that the tube is part of a series resistor network, the OC3 will maintain a constant voltage of 105 volts at the point at which its plate is connected. It will do this under a current variation of 5 to 40 ma.

When sufficient voltage is placed across the elements of this tube, the gas will become ionized and the tube will conduct. As stated above, if the circuit components are properly chosen, the tube will maintain a constant voltage (within one or two volts) on that part of the circuit controlled by it. One operating requirement is that current through the tube must not fall below 5 ma. If current does drop below that figure, the tube will stop conducting.

The symbol and base diagram of the OC3 are shown in Fig. 7. Notice there is a connection between pins 3 and 7. This is a jumper, put there to protect circuit components from unregulated voltage. If the tube is removed from its socket the circuit controlled by the tube will be disconnected from the voltage supply.

The OA4G is a cold cathode triode used as a relay tube. In use its plate is connected to the full supply voltage (105 to 120 volts), but conduction is prevented by the grid. When a positive potential of 70 volts is placed on the



BASE CONNECTIONS SYMBOL

Fig. 7

grid ionization will take place. Conduction begins between grid and cathode but is quickly transferred to the plate. The OA4G will carry a peak current of 100 ma., average current 25 ma. The symbol for this tube is shown in Fig. 8.

This concludes the description of electronic tubes used in accessory equipment in our composing room. Circuit diagrams and more detailed information on their use will be given in later instalments covering the apparatus in which the tubes are used.

There is another tube, the photo-cell, used in the electronic mat detector which should be mentioned here. This is a small clear glass tube about 9-32 in. diameter by 1⅛ in. long. A spot of light-sensitive material is applied to the inside surface of the tube. This material has the property of changing electrical resistance under influence of light. Two wires sealed into the end of the tube make contact with the sensitive coating and form the means of connecting the tube into a circuit. The tube has a resistance of several megohms in total darkness, which drops to as low as 40,000 ohms when illuminated by the lamp of the mat dector. In use, then, the tube may be considered to be a variable resistor which can be adjusted by varying the intensity of light striking the sensitized spot of the tube. This varying resistance can be used to control bias on the grid of a tube, which in turn can control other apparatus.

USE THIS CHART TO TEST THE TUBES LISTED

Tube	Type	Fil.	Plate	Top	Bottom
OA4G	4	Off	40	G	BE
		Meter reads 20 to 30.			
OA4G	4	Off	44	E	BG
		Meter reads in green			
OC3	4	Off	30	E	BCG
		Good tube reads 10			
2050/2051	3	6.3	17	CEF	GH
2D21W	3	6.3	18	AEFG	BD

Electrical Safeties

The Electromatic safety system is designed to prevent damage to matrices and-or machine when shifting magazines. Two models are in use in Opubco's composing room, one type on Model 30s and another on Model 36s. The two models are very similar and only the Model 36 will be described here.

The system is designed to prevent shifting magazines if there are matrices on distributor bar, in distributor box or caught between magazine and channel entrance. It consists of the following:

a. A switch operated by the distributor shifter.
b. Insulated distributor bars.
c. Channel entrances with moveable upper and lower plates arranged to operate a snap action switch.
d. Solenoid latch to lock magazine elevating mechanism.
e. Safety circuit switch operated by matrix guard lever.
f. Indicator lights.
g. Power supply box.
h. Wiring harness.

Model 30 has all the above features except c, and it has only one indicating lamp.

OPERATION

When matrices are in the distributor box, on the distributor bar or lodged between the channel entrance and magazine, a locking latch which locks against a toothed wheel on the magazine elevating shaft, prevents the operator from shifting magazines. The latch is held against the wheel by spring action.

There are two green indicating lights located to the right of the operator. The left-hand lamp lights whenever the distributor box and distributor bars are clear of matrices. The right-hand lamp lights when the operator depresses the automatic matrix guard handle preparatory to shifting.

When the operator ls ready to shift magazines he waits for the left-hand light to show green which means that matrices have cleared the distributor box and bar. He then presses the automatic matrix guard handle and starts turning the one-turn shift handle. If the right-hand light remains green he can complete the shift. If it does not remain lighted, however, the operator cannot shift because the locking latch contacts a projection on the toothed wheel and prevents shifting. Failure of the right-hand light to show green in this case means that a matrix or matrices are caught between the channel entrance and the magazine.

To keep the distributor signal light from flickering when a single matrix is on the distributor bar, an electronic switch and time delay circuit is employed. This consists of the Thyratron tube, 270 thousand ohm resistance R5 and the 2 mfd. condenser C2. The split-second delay in the control grid circuit allows for the momentary breaking of the circuit to ground, as the single matrix may not be making full contact with the distributor bar at times as it travels the length of the bar.

DISTRIBUTOR BAR SAFETY

The distributor bar is insulated from the distributor bracket by a nylon insulating strip. Screws and nuts which hold the bar in position are also insulated and dowels are made of nylon so that the bar is completely insulated. The bars are connected so that a matrix on either bar will complete a circuit to ground and by means of an electronic switch, the safety circuit will remain open and the solenoid latch will remain in locked position until all the matrices have cleared the bar.

ELECTRONIC SWITCH

The presence of matrices on the distributor bar or in the distributor box results in the grounding of the electronic tube circuit. The Thyratron tube controls the action of a small relay which in turn performs the switching action and subsequent energizing or de-energizing of the latch solenoids. When the distribution system is clear of matrices, the Thyratron tube is conducting current causing the relay contacts to close. When the distributor bar is grounded by a matrix, the tube stops conducting, the small relay opens, and the latch solenoid is de-energized, permitting the latch spring to pull the latch against the toothed wheel to prevent shifting of magazines.

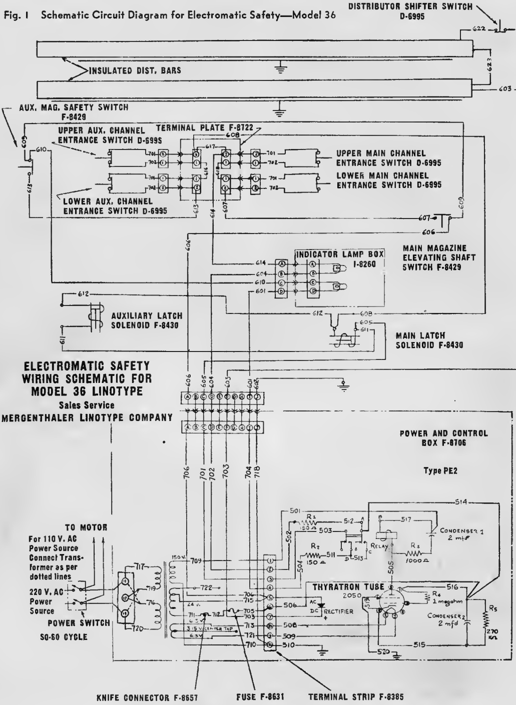
CHANNEL ENTRANCE

The channel entrances have a movable plate at the magazine end in addition to the matrix guard. A snap-action switch is mounted on the lower movable plate so that any movement of either movable plate will open the switch and break the circuit. If, while attempting to shift magazines downward, a matrix is caught between the channel entrance and the magazine, the lower plate will be moved downward by the matrix. Before any damage can occur, however, the switch opens and the solenoid latch prevents further movement of the magazine elevating shaft. If the shifting of magazines is upward, the upper plate or matrix guard will be forced upward by the matrix and the same action takes place, with further shifting prevented.

FAIL-SAFE OPERATION

The Electromatic safety works on a fail-safe principle. That is, in the event of power failure, the safety operates so that the magazines cannot be shifted, thereby making the presence

Fig. 1 Schematic Circuit Diagram for Electromatic Safety—Model 36



of the failure evident and preventing damage. However, it is possible where necessity makes it imperative to shift magazines to simply hold the latch back off the toothed wheel so the magazines can be shifted until the difficulty is eliminated.

CIRCUITS ANALYZED

Fig. 1 is the complete schematic diagram for the Electromatic safety. All components are shown on this drawing, many of them identified by part number. Wires are shown numbered and wires in the apparatus are labeled with these same numbers, making it easy to identify them with corresponding lines on the drawing. Fig. 2 is a simplified or basic diagram of the Thyratron tube circuits, while Fig. 3 is a diagram of the 24 VAC circuits.

Turning first to Fig. 2, we see that power for all circuits is supplied by a transformer. The filament of the 2050 tube is heated by current from the 6.3-volt secondary winding on the transformer and grid bias voltage is taken through a dry disk rectifier from the 24-volt secondary.

Tracing the plate circuit, we see that one end of the 150-volt winding of the transformer is grounded. The opposite end of this winding is led to the plate of the 2050 tube through the coil of the relay. The cathode of the tube is grounded, so there is a circuit from the transformer secondary through ground to the cathode, through the tube to its plate and back to the transformer through the relay coil.

The grid circuit leads from the 24-volt secondary through the fuse to a junction of C2 and the 270,000-ohm resistor. These components are connected in parallel with one junction connected to ground. The tube's control grid is connected through a 1-megohm resistor at a point between the fuse and the junction of C2 and the 270,000-ohm resistor. Looking now at the distributor bars and distributor shifter switch, we see that they are connected to the negative side of the dry disk rectifier and thence to the 24-volt secondary. The distributor shifter switch is shown as it is wired—in normally closed position. The switch is held open by the distributor shifter at the limit of

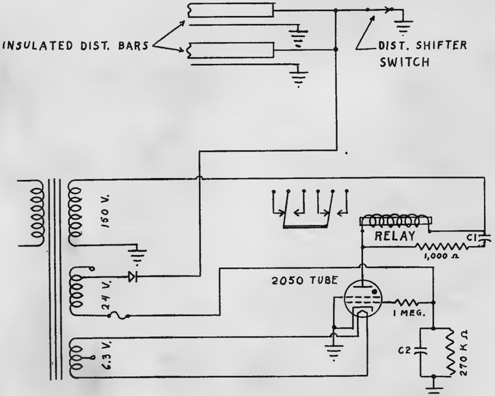


Fig. 2 Electronic Switching Circuit

its travel into the distributor box, which occurs only when there are no mats in the box.

To analyze the action of the circuit in operation, assume there are no mats in the distributor box or on the bars. The distributor shifter is at the extreme limit of its travel into the box and is holding the switch open. Under these conditions the grid circuit will be open and there will be no bias on the control grid and the grid circuit can be disregarded for the moment.

With current flowing through the filament of the 2050 tube, the cathode will be heated and thermionic emission will occur. Plate current will flow (on alternate half cycles) from the 150-volt winding, through ground to the cathode, thence to the plate, through the relay coil and back to the transformer winding. On opposite half cycles the tube will not conduct and no current will flow in the plate circuit. The tube will be functioning as a half-wave rectifier and its rectified current will energize the relay coil and hold the relay contacts in operated (closed) position.

Because of the pulsating nature of the half-wave DC supplied by the tube, the relay armature would probably vibrate and emit noise. To prevent this, a filter, consisting of a 2-mfd. condenser (C1) and a 1,000-ohm resistor is connected across the relay coil. On positive half cycles when the tube is conducting, current flow divides, part of it going through the coil and part through the resistor, to C1. On these positive half-cycles C1 is charged. On negative half cycles, when no current flows through the tube, the condenser discharges through the coil and resistor, holding the armature against the core and preventing chatter. The resistor serves to limit current.

Suppose now, that the machine has cast a line and the second elevator is lifting the matrices up to the distributor box. The distributor shifter will move out to receive the line of matrices and this action will permit the distributor shifter switch to close. It will remain closed until the last mat is pushed through the distributor box. Examination of Fig. 2 will show that closing this switch completes the grid circuit, placing a negative bias on the control grid of the tube which will cut off plate current and open the relay. Notice also, that the wiring to the distributor bars places them in parallel connection with the distributor shifter switch. A mat on either bar will form a connection between the bar and the distributor screws (represented by straight lines on the drawing) which are grounded and will complete the grid circuit, cutting off plate current.

To see how the control grid functions, begin by tracing the circuit. As described in the preceding paragraph the grid circuit will be closed whenever there are one or more mats in the distributor box or on either distributor bar. Under this condition, current will flow from the 24-volt transformer winding, through the fuse to the 270,000-ohm resistor to ground. From ground, current flows through the distributor shifter switch or through a mat or mats to a distributor bar, thence through the dry disk rectifier back to the transformer. This arrangement places ground at positive potential. The voltage drop through the 270,000-ohm resistor becomes the grid bias and the grid will be negative with respect to ground because it is connected to this resistor at the end opposite to ground. Since the cathode is connected directly to ground, the grid will be negative with respect to the cathode. This negative grid bias will cut off plate current and de-energize the relay.

Mats moving across the distributor bar, have varying degrees of contact and in the case of a single thin mat there may be moments of no contact at all. If nothing were done to prevent it, the tube would resume conduction at each moment the mat lost contact between bar and screw. The result would be erratic operation of the relay and flickering of the safety light during the progress of such a single thin mat along the bar.

To prevent this, C2 is connected across the 270,000-ohm resistor. While the grid circuit is closed, this condenser will charge. When the circuit is opened, this charge will maintain bias on the grid of the tube. At the same time, its charge will "leak" off through the resistor, quickly falling below the value necessary to maintain cut-off, and the tube will again conduct. Thus the resistor and condenser give a time-delay action which smoothes out the control action of the tube.

Fig. 3 is a shematic diagram of the 24-volt AC circuits which include the indicating lamps, auxiliary and main latch solenoids, auxiliary elevating switch, main elevating switch, auxiliary and main channel entrance switches. The action of each of these components has been discussed in previous paragraphs. The circuits are quite simple and tracing them on the diagram will show how they work.

Starting from the 24-volt winding of the transformer, through the fuse, current flows to the center contact of the right hand set of the relay. If the relay is energized its NO contacts will be closed, current will flow to the NO contact of the right-hand set. The NO contact of the left-hand set is connected to the NO contact of the right-hand set. A wire leads from this junction through a 150-ohm resistor to the distributor indicating lamp. From this lamp, there is a connection directly back to the transformer. Thus at any time the relay is energized this lamp will be lit indicating distributor box and bars are clear of mats. Coming back to the relay, current flows from the NO contact of the left-hand set to the center contact and thence to one side of each latch solenoid, which are parallel connected. Thus we see that

QUICK CHECK

It should be noted that all wires have code numbers for easy identification and these numbers are also indicated on system and schematic wiring diagrams.

In order to determine if the power and control box F-8706 is functioning properly connector plug F-8408 to main harness should be pulled out. When an undesired ground condition is existent in the harness or distributor bar insulation and the control box is functioning properly, the relay should immediately click "on" as the plug is pulled out. This action indicates that the trouble is somewhere in the circuit outside the power and control box. Refer to section under heading "The Power Supply and Control Box" for further details.

The harness circuit and component parts can be checked as follows:

1. Check adjustments of Distributor Shifter Switch and Magazine Elevating Shaft Switch and Channel Entrance Movable Plate Switches to see that they are being properly actuated mechanically.
2. To check the distributor bars for accidental grounds, it is necessary to disconnect each bar, one at a time, from the circuit. This is simply done. To check lower distributor bar, disconnect wire (No. 623) which connects upper and lower bars, from the upper bar. If the lower bar and circuit to the power and control box is correct, the safety system should now operate satisfactorily when the Matrix Guard Lever is depressed. To check upper distributor bar, the wire (No. 603) from the main harness to the lower bar must be disconnected and temporarily attached to the upper bar. Wire (No. 623) which connects the two bars must also be removed. If the upper bar is not grounded and the circuit to the power and control box is all right, the safety system should operate satisfactorily upon depressing the Matrix Guard Lever and it can be assumed that the trouble lies elsewhere.
3. If, after checking both distributor bars and the power and control box, as described in sections 1 and 2 above, the source of trouble is not located, the next step would be to check the wiring of the main harness to see that all wires are securely fastened in place and that no grounding or short circuiting has occurred between wires. Wires are code numbered at both ends for easy identification.
4. The seven switches should be checked by means of a lamp testing outfit or ohmmeter to see that they are opening and closing properly.

Over a long period of time, the rectifier may age so that the D.C. output will not be the required minimum necessary to cause the Thyraton tube to stop conducting. Rectifier D.C. output can be checked with a D.C. voltmeter by measuring between terminals 6 and 7 on terminal strip F-8385. Plus lead of voltmeter should be on terminal 7. D.C. voltage should be approximately 10 volts D. C. plus or minus 5 percent when power supply is 110 or 220 volts A.C.

If the rectifier is not producing the required voltage, the presence of matrices (particularly a single thin matrix) on the distributor bar may cause the distributor indicating light to flicker. In this case the action of the relay in the power and control box will be erratic and consequently the locking action will not be positive.

The rectifier, Thyratron tube, and time delay circuit can be checked as follows:

1. Disconnect the main harness from the power and control box F-8706 by pulling out the amphenol connector plug F-8408.
2. With power on, carefully touch one end of an insulated piece of wire to terminal 7 of the power and control box terminal strip F-8385 and brush the other end of the wire back and forth on terminal 10. This simulates the same condition of a single matrix traversing the distributor bar.
3. If rectifier, tube and time delay circuit are operating correctly the relay should open and remain open as the wire momentarily leaves and returns to terminal 10. Holding the wire across both terminal 7 and 10 steadily, should, of course, result in the relay remaining open until shortly after the wire is lifted from the terminals.
4. If relay does not remain open the rectified direct current output should be checked with a D.C. voltmeter to be sure there is approximately 10 volts D.C. output between terminals 6 and 7.

Check resistance R5 and condenser 2 with an ohmmeter. Resistance R5 should be approximately 270 thousand ohms. To check condenser connect one ohmmeter lead to either terminal of the condenser 2 (with all wires to condenser disconnected) and the other test lead to ground. The resistance as measured from either terminal to ground should be infinite. If values of voltage and resistance as given above are not approximately close, the offending part should be replaced.

TTS-OPERATED COMET SAFETIES

When certain malfunctions occur, it is desirable to have the Teletypesetter operating unit stopped and held automatically until the trouble can be corrected. This is the purpose of the Comet safeties. The group consists of:

a. Clutch magnets
b. Tape-out switch
c. Tight-tape switch
d. Last mat kicker switch

e. Dist. switch
f. Assem. belt shifter switch
g. Anti-jamb switch
h. Delayed start switch
i. Mat detector relay
j. Last mat kicker solenoid
k. Signal light
l. Power supply

The clutch magnets and three switches (a through d) are located on the operating unit. The anti-jamb, delayed start switch and mat detector relay are features added in Opubco's composing room.

The system operates on approximately 24-volts DC supplied by transformer and rectifier in the power supply box. Except the last mat kicker switch, delayed start switch and the tight-tape switch, all switches and contacts on the mat detector relay are wired in parallel. Closing any one of these switches will energize the clutch magnets and stop the TOU, and the TOU will be held inoperative if any of the following occur:

Distributor stops, assembler belt shifter is pushed to stop position, end of tape enters reading head, mats pile up under chute finger causing anti-jamb switch to be closed, or if a missed mat or no-cast is detected by mat detector the relay will close. Any of these events will stop the TOU and light the signal lamp.

The delayed start switch is operated by the delivery lever cam roll arm. It is wired through a toggle switch located on the front of the machine which allows the delayed start switch to be cut out when desired. In operation the delayed start switch will hold the TOU while an assembled line of matrices is delivered into the first elevator jaws and the delivery slide returned to normal. This action gives more time for matrices to be distributed which is desirable under certain operating conditions as when casting long measure.

The tight-tape switch is operated by a lever which is lifted by the tape being fed into the TOU. It is most commonly used when operating with re-perforators. The switch is a single pole, double throw unit so wired that it disconnects the signal lamp before operating the clutch magnets.

The last mat kicker switch is operated by a cam on the elevating shaft of the TOU. As this shaft starts to rotate, the switch is momentarily closed energizing the last mat solenoid. The solenoid depresses the assembler slide brake extension finger, releasing the brake and allowing the assembler slide spring to pull the slide back and tighten up the line. This action tends to stand the mats up straight and occurs just before the line is lifted for delivery to the first elevator.

The schematic diagram of the system is given in Fig. 4.

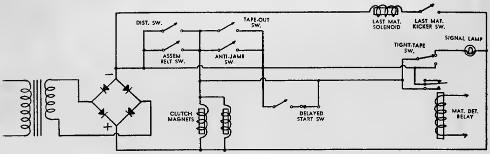


Fig. 4 Schematic Circuit Diagram for Comet Electrical Safeties

Electronic Mat Detector

How It Operates

The Shaffstall Electronic Mat Detector combines principles of electronic timing, electronic memory and the photo-electric eye. Its purpose is to stop the line-casting machine whenever a mat is missed in a line or when a line fails to cast. Before taking up the circuitry, which is rather complex, we will discuss briefly the operation of the device.

When the TOU depresses a key on the line-casting machine keyboard, the bell-crank lever of the operating unit moves the contact bar of the mat detector, momentarily closing the contact bar switch points. This action charges the memory condenser and starts a charge of the timing condenser which will cause the elevator lock to be actuated in a given number of milliseconds (depending on the speed of the machine) if a mat fails to leave the magazine for the key that was pressed.

The cancellation of this memory and stopping of the timing cycle is accomplished by the photo-electric eye. A mat leaving the magazine and breaking the light beam which scans the front of the magazine causes the photo circuit to actuate two relays which discharge both the memory and timing condensers.

If a mat sticks part way out of the magazine thus continuously obstructing the light beam, a safety circuit is closed through one pair of points of the right hand relay in the control box and when contact points located over the elevator cam shaft are closed by the rotation of this shaft at the end of the line, the elevator lock is actuated holding the line from elevating due to the fact that one or more mats may be missing from the line.

Should a line fail to cast the elevator lock will hold the line that is being assembled at the time the cast was missed.

It should be pointed out that certain alterations have been made on this equipment in Opubco's composing room. While the basic circuits and circuit components are unchanged, wiring has been re-arranged and certain elements re-located. As a result, equipment supplied by the factory must be reworked to conform before it can be interchanged with equipment on our machines. An exception to this rule is the control box which is interchangeable.

In addition, a relay has been installed to cause the mat detector to actuate the TOU clutch magnets. This refinement causes the tape to be stopped almost immediately when a mat is missed or a line fails to cast.

Schematic Circuit

The accompanying folding plate (Fig. 2) contains the complete schematic circuit of the mat detector. The broken lines enclose the elements contained in the various units, such as power box, control box, etc.

The mat detector features plug-in units so that they may be quickly removed from the machine for repair or replacement. This is shown on the schematic diagram, where sockets and plugs are lettered to correspond. In tracing circuits a connection should be assumed from any numbered pin on a plug to the same number on the matching socket. Thus there is a connection from No. 1 on plug A to No. 1 on socket A, and from No. 2 on plug A to No. 2 on socket A, and so on. Wiring from the base unit to plug E which connects to the indicator box is carried through an 8-wire cable. The wires are color-coded as indicated on the drawing.

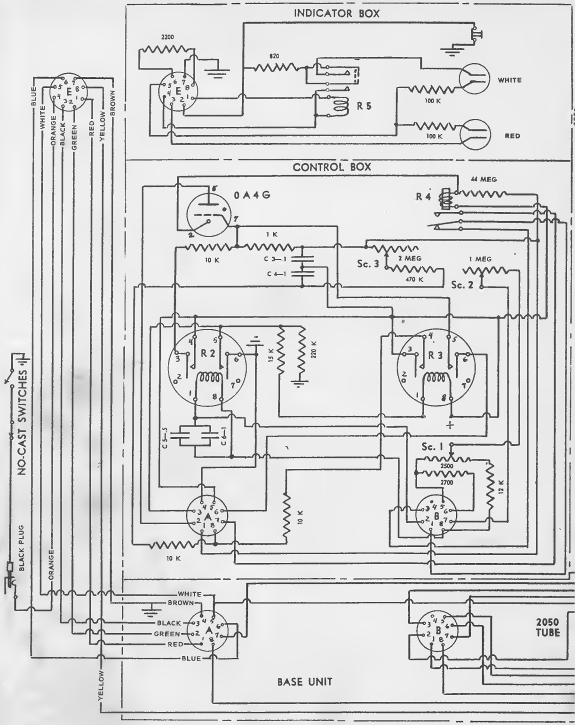
Power Supply

Power for the mat detector is taken from 115-volt supply lines to a power transformer located in the power box. The line enters the base unit which it is taken through two 2-amp. fuses, then to a DPST toggle switch. From the switch the line goes through pins 2 and 7 of plug D and socket D, thence to the primary winding of the transformer. There are no other connections to the power line. The transformer serves to completely isolate the mat detector components from the power line. Two secondaries on the transformer give voltages of 6.3 and 120 respectively. The 6.3-volt winding supplies power to the lock solenoid, the lamp and the filament of the 2050 tube. All other circuits are powered by the 120-volt secondary.

The output of the 120-volt secondary is divided. Some circuits are supplied 120 VAC directly from the winding. Other elements require DC and this is supplied by a small dry-disk rectifier and 40-mfd. filter condenser (C1). The DC voltage is fed to a circuit containing an OC3 tube to give a regulated output of 105 volts. How these voltages are used will be shown as the various circuits are discussed and analyzed.

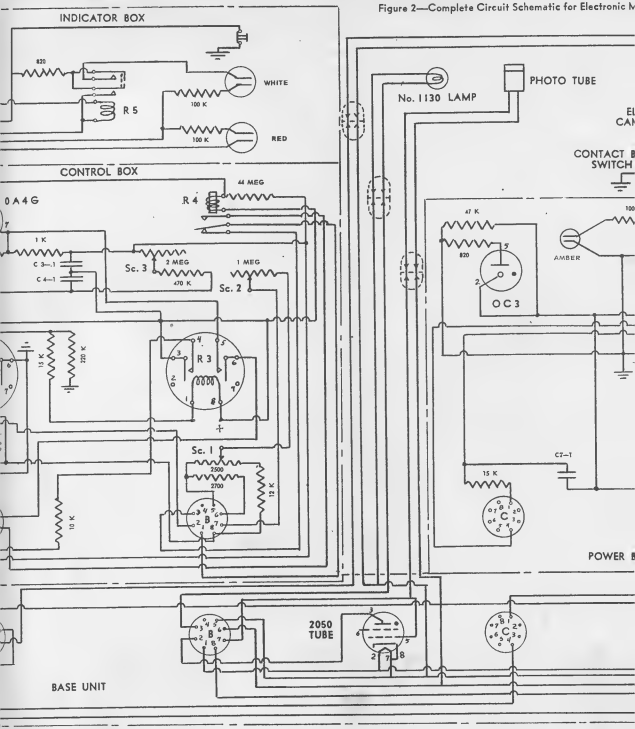
6-3-Volt Circuits

Figure 3 is a diagram of the 6.3-volt circuits. Leads go directly to filament connections 2 and 7 on the socket for the 2050 tube. From No. 2, one lead goes to the center contact of the relay R4. From R4 through the normally closed contact, the lead goes to the lamp and from the lamp back to a junction with the lead to No. 7 on the tube socket. Thus we have a circuit through R4 to the lamp so long as R4 is not energized. If R4 is energized, the center contact will be pulled away from the NC contact, opening the circuit and extinguishing the lamp. As the center contact is pulled further toward the core it will close a circuit through its NO contact. This circuit



INDICATOR BOX
2200
620
R 5
WHITE
RED
100 K
100 K
CONTROL BOX
0A4G
44 MEG
R 4
1 K
10 K
C 3—1
C 4—1
Sc. 3
2 MEG
470 K
1 MEG
Sc. 2
R 2
R 3
15 K
220 K
C 5—.5
C 6—1
Sc. 1
2500
2700
12 K
10 K
10 K
NO-CAST SWITCHES
BLACK PLUG
BLUE
WHITE
ORANGE
BLACK
GREEN
RED
YELLOW
BROWN
WHITE
BROWN
BLACK
GREEN
RED
BLUE
YELLOW
ORANGE
2050
TUBE
BASE UNIT

Figure 2—Complete Circuit Schematic for Electronic M



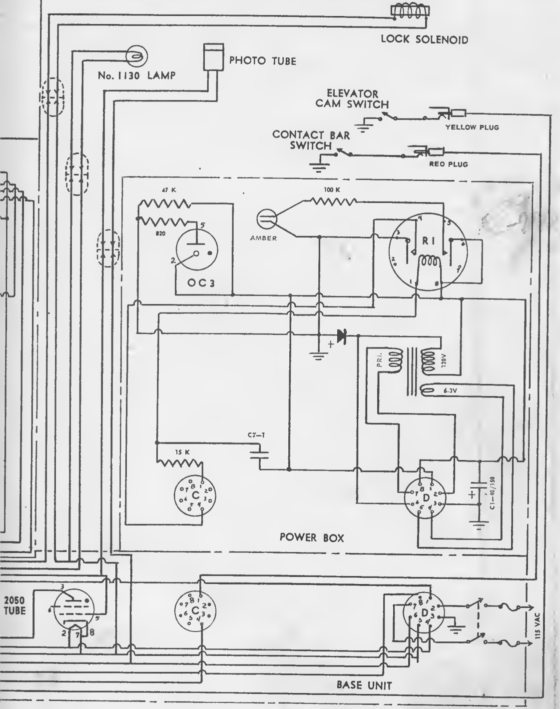


Figure 2—Complete Circuit Schematic for Electronic Mat Detector.

leads to the lock solenoid and back to a junction with the lead to No. 7 on the tube socket. R4 is energized whenever the OA4G tube is conducting. Thus we see that under normal conditions when the OA4G tube is not conducting, R4 is unoperated, the lamp is burning and the lock solenoid is de-energized. If the OA4G is fired, the relay will be energized, extinguishing the lamp and activating the lock solenoid to prevent the rise of the assembling elevator.

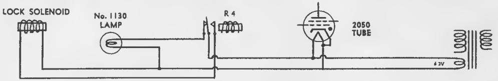


Figure 3—Diagram of 6.3-Volt Circuits.

Memory and Timing Circuits

To find out what causes the OA4G to fire we will start where the action starts—with the contact bar. This bar is moved by the bell-crank levers of the TOU whenever one operates a key on the linotype keyboard. Its movement allows the points of the contact bar switch to close. The diagram in Fig. 2 will show that closing the contact bar switch will complete a circuit through the coil of R1. Tracing the circuit, we see that current flows from the 120-volt secondary up to pin 8 of R1, through the coil, out at pin 1, down through the 15K resistor to pin 1 of socket C. From pin 1 of plug C through the red plug to the contact bar switch. This switch, when closed, connects the line to ground. From ground, current flows through the rectifier back to the transformer.

Notice that there is a 1 mfd. condenser (C2) in the power box. Tracing its connections will show that it is across the coil of R1. In action this affects the timing of R1. Increasing the speed of the linotype would necessitate greater capacitance here to "synchronize" the timing circuit.

Now, examine R1. It has two pairs of contacts, normally open. One pair—5 and 6—when operated, closes the circuit to the neon lamp (amber). Closing of the contact bar switch is always of momentary duration and R1 follows its action, so the amber light may be said to flash rather than glow. Its flashing is an indication of the functioning of the switch and relay.

The second pair of contacts on R1 (pins No. 3 and No. 4) close a circuit to charge the memory condenser. Tracing the circuit in Fig. 4 will show that while R1 is energized the memory condenser C4 will charge from the DC supply. The timing condenser (C3) will begin to charge but, due to the high resistance in its circuit, R1 will open before it is fully charged. Now, C4 will begin to discharge into C3 due to the fact its full charge is at a higher voltage than the partial charge on C3. The rate at which this action goes on is determined by adjusting the 2-megohm potentiometer (Screw No. 3).

The timing condenser C3 is connected to the grid of the OA4G tube through a 1,000-ohm resistor. As C4 continues to discharge into C3 the voltage on C3 becomes higher and higher until it reaches a value sufficient to fire the OA4G tube. When fired, the OA4G will draw current through the coil of R4 causing it to extinguish the lamp and energize the lock solenoid. This action was described under "6.3-Volt Circuits". The OA4G plate lead is carried to ground through the push button located on the front of the indicator box. Since the OA4G is operating on DC it will conduct and hold R4 energized so long as this current is uninterrupted. Pressing the push button breaks the plate circuit, the tube stops conducting and

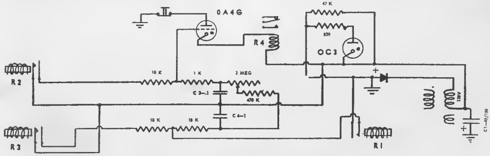


Figure 4—Memory and Timing Circuits.

the relay R4 is restored to its normal unoperated condition.

The action charging C3 is started each time the TOU operates to depress a key on the linotype keyboard. If nothing is done to prevent the condenser receiving a full charge, the OA4G tube will be fired as often as it is cleared (by pressing the push button) while the TOU is running. Since the purpose of the device is to detect failure of mats to fall, the tube must be allowed to fire only if such a failure occurs.

Referring to Fig. 4, notice that R2 and R3 each have a pair of contacts wired into the memory and timing circuits. These two relays act together and are controlled by the 2050 tube, which in turn is caused to conduct by interruption of light falling on the photo-cell. This light beam is interrupted each time a mat falls through it. The circuit involving the photo-cell and the 2050 tube will be taken up in a following paragraph, but first let us see the effect on the memory and timing circuits. The contacts on R2 are connected across C3 through a 10K resistor and a 1K resistor in series. Closing these contacts will discharge C3 through the two resistors. Similarly, contacts on R3 are connected across C4 through two 10K resistors in series. Closing these points will discharge C4 through the resistors.

Thus it is, that each time a key is operated the timing cycle is started. If the mat for which the key was pressed breaks the light beam before the cycle is completed the timing action is stopped and the circuit conditioned for the next key operation. If the mat is slow or does not fall at all, the tube fires and the line is held.

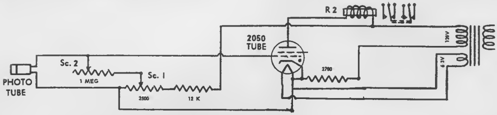


Figure 5—Electric Eye Circuits.

Photo-cell Circuits

The photo-cell is located near the bottom of the magazine at its left side. A lamp house is mounted at the right side from which a beam of light is directed across the bottom of the magazine to the photo cell. The lamp and photo-cell are so aligned that mats leaving the magazine fall through the beam and cast their shadow on the photo-cell.

The photo-cell is of the type which changes resistance with variation of light intensity. It is connected into the grid circuit of the 2050 tube in a manner that causes the tube to conduct while the cell is in darkness. How this is done may be understood from a study of Fig. 5.

The 2050 tube has its filament connected to the 6.3-volt secondary of the power transformer. When the tube is conducting, current will flow from the 120-volt secondary through the 2700-ohm resistor to the cathode. From the plate, the current goes through the winding of R2 back to the transformer. The tube will function as a rectifier and will conduct only on those half-cycles when the plate is positive, or on positive half-cycles. During a positive half-cycle, the lead from the relay coil to the transformer will have a higher positive potential than any other part of the circuit and the lead from the transformer to the 2700-ohm resistor will be the most negative. The action described below occurs only during positive half-cycles. While the tube is conducting, current will flow through the 2700-ohm resistor and there will be a resulting voltage drop across this resistor. This means that the cathode will be more positive than the negative lead from the transformer by the amount of voltage drop across the resistor. This fact allows grid bias to be taken from the same source that supplies plate current.

Notice that the 2500-ohm potentiometer (Screw 1) and the 12K resistor form a voltage divider across the transformer secondary. A lead from the 2500-ohm potentiometer connects to the negative lead from the transformer and the 12K resistor is connected to the opposite side of the transformer. The arm of the potentiometer is connected to the 1-megohm variable resistor (Screw 2). This variable resistor and the photo-tube are connected in series and the two connected in parallel to that portion of the 2500-ohm potentiometer between the contact arm and its lead to the transformer.

With this arrangement Screw 1 and Screw 2 can be adjusted to give a cut-off bias on the grid of the 2050 tube. This is done with full illumination on the photo-tube. When the photo-tube is darkened, its resistance jumps to a very high value. This has the effect of increasing the resistance in that part of the voltage divider below the potentiometer arm. It is as if this contact arm were moved toward the positive end of the potentiometer. The result is the bias on the tube's grid is made less negative and the tube conducts. Its plate current,

passing through the coil of R2 will energize this relay and cause its contacts to be closed.

Relay Functions

We have already seen how R2 and R3 stop the timing cycle and discharge both C3 and C4 when the 2050 tube is conducting but this is not all they do. Refer to Fig. 2 and examine the circuits involving R2. First, there is the coil (pins 1 and 8). Tracing the line from No. 1 through pin No. 2 of plug B, we come to the plate of the 2050 tube. Backtracking current flow further, the cathode connects to the filament (No. 8 to No. 7) and on to pin No. 5 of plug B. From here, through the 2700-ohm resistor, the path goes to pin 6 on plug B, thence to pin 6 of plug D and on to a connection with the transformer secondary and completing one side of the circuit. Tracing the other side, from pin 8 of the relay, go to 8 on plug B, thence to 8 on plug D and on to the transformer. Thus, when the 2050 tube is conducting, R2 is energized by the half-wave DC output of the tube. The condensers C5 and C6 serve as a filter to smooth out the pulsations and prevent chatter. Probably, also, they have an effect on timing of the relay's action.

Now, with R2 energized, tracing the leads from contacts 3 and 4 will show they are connected across C3 and when closed will discharge the timing condenser through the 10K and 1K resistors. The lead from contact 5 on R2 goes in two directions. Going to the left, it leaves the control box through pin 3 of plug A, on to the indicator box and a connection to the red neon lamp. The lamp circuit is completed through a 100K resistor and connection to the transformer through pin 5 of plug E and 1 of plug D. No. 6 contact of R2 goes to ground, so closing contacts 5 and 6 completes a circuit to the red lamp causing it to glow.

Following the lead from contact 5 to the right, it goes to pin No. 1 of R3 through a 15K resistor. Pin 1 is one terminal of the coil of R3, the other terminal is No. 8. From 8 the lead is to 5 of plug A and on to the transformer. As we have just seen, contact 6 of R2 is connected to ground which is the plus side of the DC voltage supply, so closing contacts 5 and 6 energizes R3 from the DC source. The small rectifier across the coil of R3 is to kill off fly-back current from the coil and protect the contacts of R2 from arcing. The 220K resistor from contact 5 on R2 to ground was previously installed for this purpose.

Looking now at R3, we have seen that this relay is operated by contacts on R2 and will follow the action of R2. Contacts 3 and 4 of R3 are connected across the memory condenser through two 10K resistors in series. Closing 3 and 4 will discharge C4 through these resistors.

Contact 5 leads directly to the OA4G grid while 6 goes to pin 6 of plug A thence to a 2200-ohm resistor in the indicator box by way of pin 6 of plug E. From the 2200-ohm resistor, through 8 of plug E the lead goes through the yellow plug to the elevator cam switch. If a mat sticks part way out of the magazine in such a way as to continuously obstruct the light beam the mat detector would become inoperative. The 2050 tube would be conducting, holding R2 and R3 energized and their closed contacts would prevent any charge being placed on C3 or C4 so no timing cycle could be started. To prevent this going on indefinitely the circuit to contacts 5 and 6 of R3 was devised. When the condition described does exist, matrices will be assembled to the end of the line. Then as the elevator cam shaft begins to revolve the elevator cam switch will be closed. This will place the necessary positive voltage on the grid of the OA4G to fire it, energizing R4 and the elevator lock and holding the line.

The No-Cast Circuit

There remains only one more function of the mat detector to be examined. This is the no-cast feature. The circuit includes the no-cast switches, the OA4G tube, relays R4 and R5, both the red and white lights and the push button. The two no-cast switches are wired in series. One is mounted on the pot pump bracket and so positioned that it is held closed by the pot pump lever in its normal position. The second switch is located so that it will be momentarily closed by a cam revolving on the main cam shaft. Timing is important here. When operating normally, the switch on the pump bracket will be open while the plunger is descending to make a cast and returning to normal. While this switch is open, the other will be momentarily closed by the cam passing over it. Thus both switches are operated without closing the circuit. Now if either of the pump safety stop levers hold the pot pump lever up, preventing a cast, the switch on the pump bracket will be closed when the second switch is closed by the cam and the no-cast circuit will be completed. What happens next involves an interesting and unusual bit of circuit design.

We have seen how the OA4G is fired by the timing condenser when its charge reaches a voltage that will trigger the tube. A second means of firing the OA4G involves the elevator cam switch and contacts 5 and 6 on R3. In this case a positive voltage is placed on the grid by connecting it to ground through a 2200-ohm resistor. In both instances, the tube energizes R4, extinguishing the lamp and activating the elevator lock solenoid. A third means of firing the tube is used in the case of a no-cast.

We have previously traced the circuits to the OA4G tube and know that it is conditioned to fire whenever a plus voltage of sufficient value is applied to the grid. In tracing the no-cast circuit we need only to trace the source of grid voltage. Looking at Fig. 2 we see the

two no-cast switches at the extreme left of the drawing. Imagine that a cast is missed and both switches are closed. Starting at ground which is DC positive, the line goes through the switches, up to pin 4 of plug E and on to the bottom of the coil on R5. Leaving the relay coil, trace the line to 1 on plug E, down to 1 on plug A and into the control box. From 1 on plug A up the right side to a junction with a line coming across above the 2-meg. potentiometer. Go across this line, through the 1K resistor to the grid of the tube. So we see that closing both no-cast switches will connect the grid to a positive voltage and fire the tube.

An interesting feature of this arrangement is that the tube is caused to operate two relays. In our study of vacuum tubes we learned that when the OA4G fires, conduction starts with the grid and transfers to the plate. In this case the current drawn by the grid passes through the coil of R5 causing the relay to operate. Once closed it will be held by one pair of its own contacts through the 820-ohm resistor and push button to ground. R4 will be energized as the plate of the OA4G takes over conduction and performs its usual functions.

When a no-cast occurs, both the red and white light glow. The white light is fed through one set of contacts on R5 and this lamp can only be lit when R5 is operated and always signals a no-cast. The red light receives current through contacts 5 and 6 of R2. We have seen how the coil of R2 is energized when the 2050 tube is conducting. This tube conducts only when the photo-cell has acted to lower the negative bias on the tube. This condition may come about whenever a mat (or other object) casts a shadow on the photo-tube, or it may come, as in the case of a no-cast, from R4 being energized and extinguishing the lamp.

Component Functions

There are five relays used in the mat detector. All are for DC operation and all have 5,000-ohm coils. R1, R2 and R3 are plug-in relays and are interchangeable. Some individual plug-in relays in use in our plant are DPDT, the normally closed contacts being wired to pins 2 and 7 on the base. These are fully interchangeable with the DPST relays.

R1 is the synchronizer relay. Its coil is energized by closing the contact bar switch. Contacts 3 and 4 charge the memory condenser and start the timing cycle. Contacts 5 and 6 flash the amber light.

R2 has its coil in the plate circuit of the 2050 tube and is energized whenever this tube conducts. Contacts 3 and 4 discharge the timing condenser C3. Contacts 5 and 6 energize the coil of R3 and flash the red light.

R3 coil is energized through contacts 5 and 6 of R2. Contacts 3 and 4 discharge memory condenser C4 stopping memory and timing cycle. Contacts 5 and 6 in conjunction with the elevator cam switch fire the OA4G in cases of obstructed light beam or a burned out lamp bulb.

R4 has its coil in the cathode lead to the OA4G tube and is operated whenever this tube conducts. Its SPDT contacts feed the lamp in normal position and energize the elevator lock solenoid in operated position.

R5 has its coil wired in series with the no-cast switches and has a lead to the OA4G grid. When a cast is missed by the linotype, both no-cast switches will close completing a circuit from ground through the coil of R5 to the tube's grid, causing the tube to fire. The relay will be operated by grid conduction. One pair of its DPST contacts serve to hold the relay operated while the second pair lights the white lamp.

C1 is the filter condenser for the DC voltage supply. It is an electrolytic capacitor of 40 mfd. rated at 150 working volts.

C2—a 1 mfd. paper type condenser used in synchronizer circuit.

C3—timing condenser, 0.1 mfd. paper type.

C4—memory condenser, 1 mfd. paper type.

C5—paper condenser, 0.5 mfd., filters output of 2050 tube.

C6—paper condenser, 1 mfd., filters output of 2050 tube.

OC3 tube—regulates DC voltage to 105 volts.

2050 tube amplifies signals of photo-tube and operates R2 in response to photo-tube.

OA4G tube energizes R4 when conducting. It is fired by a charge built up on C3, by the elevator cam switch closing while R3 is operated, or by closing of both no-cast switches. In this last instance R5 will be pulled in by conduction of the grid when the tube fires.

Contact bar switch, closed by movement of TOU bell crank levers. It makes a circuit through the coil of R1 causing it to start the timing cycle.

Elevator cam switch, operated by rotation of the TOU cam shaft. Its purpose—to hold a line if light beam is interrupted or lamp is out.

No-cast switches located, one on pot pump bracket and the other depending on location of cam which operates it. Purpose of the switches—stop machine if a cast is missed.

Screw 1—2500-ohm potentiometer—adjusts bias on grid of 2050 tube.

Screw 2 — 2-megohm variable resistor—adjusts sensitivity of photo-tube circuit.

Screw 3—1 megohm variable resistor-regulates rate at which timing condenser is charged.

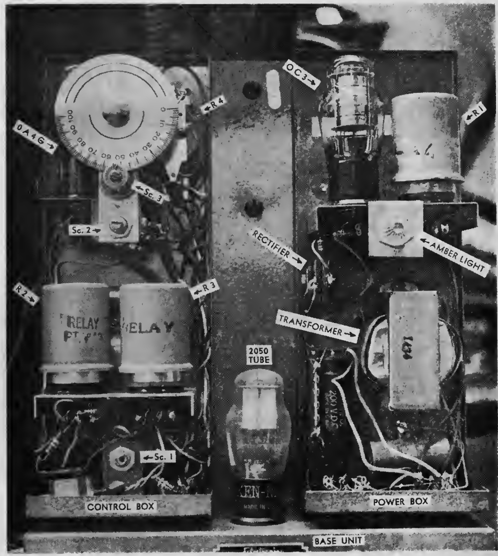


Figure 1—View Showing Mat Detector Installed on Linotype.

SEQUENCE—NORMAL CYCLE

1. Bell crank lever, moving to depress key on linotype keyboard, pushes against contact bar allowing contact bar switch to close momentarily.
2. Relay R1 is energized by circuit through contact bar switch.
3. Amber light is "flashed" during time R1 is energized by circuit through contacts 5 and 6.
4. Memory condenser, C4, charges through contacts 3 and 4. Timing condenser C3 begins to charge.
5. Contact bar switch, having opened, R1 is de-energized and its contacts open.
6. C3 continues to charge by drawing current from C4.
7. Mat, released as a result of key that was depressed, falls through light beam.
8. Shadow of mat passing over photo-tube causes it to change its resistance. This alters bias on grid of 2050 tube causing it to conduct.
9. Current to the 2050 tube energizes Relay R2.
10. Contacts 3 and 4 of R2 discharge C3. Contacts 5 and 6 flash red light and energize R3. Contacts 3 and 4 of R3 discharge C4.
11. Light falling on photo-tube restores its original value of resistance and this in turn raises bias on 2050 tube above cut-off.
12. Mat detector is conditioned for next cycle of operation.

In case the mat had failed to fall, the sequence would have been the same down through No. 6 From there on the sequence would go as follows:

7. Mat, for which key was pressed, fails to fall. Light beam is uninterruped and 2050 tube remains cut off.
8. Charge on C3 reaches voltage necessary to fire OA4G.
9. Current to OA4G energizes relay R4.
10. Normally closed contacts on R4 open extinguishing lamp.
    Normally open contacts close, energizing lock solenoid, holding assembling elevator.
11. OA4G tube is operated on DC and will continue to conduct, maintaining condition described in No. 10 until push button is pressed to break plate circuit.
12. Pressing push button conditions circuit to resume operation.

In conclusion, the reader is reminded that many actions of the mat detector are timed in thousandths of a second. It does not require much imagination to see that adjustments affecting these actions must be carefully and correctly made. It is suggested that machinists follow instructions in the manual to the letter when working on the mat detector.

NOTE: Diagrams used in this lesson were obtained by tracing the wiring of the actual apparatus. The description of how the device functions was written from a study of these drawings.

	1st 2nd Band	3rd Band	Last Band or double Thereof
Black	0		
Brown	1	0	
Red	2	00	
Orange	3	000	
Yellow	4	0000	
Green	5	00000	
Blue	6		
Violet	7		
Grey	8		
Gold			
Silver			